THE ENGINEER

A Seven-Day Journal

The Building Research Congress

THE opening session of the Building Research Congress was held on Tuesday last at the Institution of Civil Engineers. A message from His Majesty the King was read, and an address of welcome to the delegates was delivered by Lord Samuel, the president of the Congress. Dr. F. M. Lea, Director of Building Research, D.S.I.R., then delivered an address entitled "Building Research To-day," in which he gave an interesting account of various historical developments in building construction, leading up to modern research, and commented upon the wider aims of present-day activities in this field. During the course of his address Dr. Lea noted that it was in the nineteenth century that the systematic testing of materials and structural members grew apace and the early beginnings of scientific research into their manufacture, behaviour and use were made. The revolution in building that had commenced with the introduction of cast iron as a material for columns and beams at the end of the eighteenth century was hastened by the coming of steel, of modern cements, of reinforced concrete and other materials and by the progressive application of the theory of elasticity to design. The problems arising from the lighting and heating of buildings took shape, the physical knowledge of sound began to find application in design, and the recognition of the influence of building construction and sanitation on health had its outcome in building regulations. The growth of building research as an organised entity, Dr. Lea continued, had been stimulated by the growing complexity of modern materials and methods, and by the increasingly rigorous demands of the user. Laboratories for testing materials and for research in allied problems were established in the last century; but apart from them, the major contribution long remained that of the individual worker in the university or elsewhere. It was only in 1920 that the Building Research Station was set up in Great Britain, which, he thought he could justly claim, was the first to have that wide-embracing title. It was the forerunner of many others outside the British Isles. Building, Dr. Lea said, was an adventure, both technical and, he was told, economic, and its outcome was never predictable in full. Research, he concluded, could reduce its risks and increase its fruits. The Congress is the first international meeting of its kind which has been held; it will be in session until the end of next week.

The Fuel and Power Shortage

THE Combustion Engineering Association announced at the end of last week its intention to hold a conference on the subject of "Meeting the Fuel and Power Shortage" on Tuesday and Wednesday, October 9th and 10th, at the Dorchester Hotel, Park Lane, London, W.1. This event has been arranged in response to a number of requests from large industrial consumers of fuel and power for an immediate discussion of ways of meeting the situation, both during the coming winter and in the future. The principal object of the Combustion Engineering Association is to promote co-operation between manufacturers and distributors of combustion appliances and the producers, distributors and users of fuel for the purpose of securing the best possible use of the coal reserves of Great Britain. At the opening session of the conference addresses will be given by the Minister of Fuel and Power and the chairman of the National Coal Board, and they will be followed by an open discussion on the coal supply position. The programme for the first day also includes talks on the supply and effective use of gas and electricity, and an address by the president of the Federation of British Industries on "Industry's Fuel Problems." The programme for the second day of the conference includes addresses on "The Short-Term Economy" and "The Long-Term Economy," and on "The Requirements for a National Fuel Policy." All will be followed by open discussion. Full details of the conference are available from the Combustion Engineering Association, 6, Duke Street, St. James's, London, S.W.1.

Productivity in Galvanising

THE report has been published this week of a specialist team, organised by the Anglo-American Council on Productivity, which went from this country to the U.S.A. last year to study galvanising by the hot dip process. The team was led by Mr. F. C. Braby, M.I.Mech.E., and, in the course of its tour, about twenty American galvanising shops were visited. In many of the works, the report says, the technical processes were simpler and less efficient than those employed in modern British practice, but the Americans considered that to be of secondary importance compared with means to secure the maximum output. When the team arrived, supplies of zinc in the U.S.A. were becoming scarce, but, according to the report, the Americans appeared to show little interest in the possibility of conserving supplies by measures to reduce ash or dross formation. In this respect, the team considers, British galvanisers benefit from co-operative research, which is almost non-existent in the U.S.A. Most of the shops seen by the team were no bigger than many in this country, but the volume of work passing through them was much greater, indicating that the Americans make more intensive use of their capital equipment. The report observes that the number of men per galvanising bath is greater in the U.S.A. than in Britain, and the quantity of work galvanised per man-hour exceeds that in British works. A matter emphasised in the report is the thought given by the managements of American galvanising firms to ensure an even flow of work and to the handling facilities needed for particular kinds of articles. Physical effort is lightened as far as possible, by mechanical aids and by reducing each job to the simplest degree attainable. The American worker, the report states, is not apprehensive of mechanisation, "but realises that his wages ultimately depend on the firm's prosperity, which in turn depends on its productivity."

Mechanical Engineering Research

THE first progress report of the Mechanical Engineering Research Board—which was set up under the chairmanship of Sir Henry Guy in 1946—has appeared this week. The board is responsible for the Mechanical Engineering Research Organisation of the Department of Scientific and Industrial Research, and when the organisation began its work in 1947 its headquarters were in London. Much of the work described in the report, which covers the years 1947–1950, was carried out at the National Physical Laboratory. More recently, however, the organisation has been transferred to East Kilbride, Scotland, where the building of extensive laboratories and workshops is proceeding. So that the most rapid progress can be made with research, the completed laboratory at East Kilbride is to be used at first as a general purpose building for experimental work on materials, mechanics of solids, fluid flow, heat transfer, and mechanics of formation. The work of the organisation is separated into seven main divisions, as follows: properties and strength of materials; mechanics of solids, stress analysis and vibration; mechanics of fluids, including hydraulic machinery; lubrication, wear and corrosion; mechanisms and engineering metrology; mechanics of formation and machine shaping of materials; heat transfer and applied thermodynamics. The report summarises the progress made in each division up till the end of last year. When the organisation was created, Dr. G. A. Hankins, M.I.Mech.E., formerly Superintendent of the Engineering Division of the N.P.L., was appointed Director of Mechanical Engineering Research, and the work was carried on under his guidance until his death last November. Since then and pending the appointment of a successor, Dr. D. G. Sopwith, M.I.Mech.E., Superintendent of the Engineering Department of the N.P.L., has taken charge of the organisation on a part-time basis. In recording the work of the seven divisions of the organisation, the report acknowledges the valuable assistance of the universities and technical colleges in the present research programme. That assistance includes work on the fundamental reasons for fatigue failure of metals, which is being done at Bristol, fluid flow problems being studied at Cambridge, extrusion problems at Sheffield, screw thread rolling investigations at Edinburgh, and work on the mechanism of condensation, which is in progress in London.

The Women's Engineering Society

THE twenty-ninth annual conference of the Women's Engineering Society was held in London during last week-end. It began with a tour of the Science Museum, South Kensington, on Friday morning, during which Mr. G. Tilghman Richards, M.I.Mech.E., gave a lecture entitled "Man and the Machine." The annual dinner, which was attended by about sixty members and guests, took place on Friday evening, with the president, Miss Sheila Leather, in the chair. The toast of "The Society" was given by Colonel B. H. Leeson, M.I.E.E., who traced the growth and development of the Society since 1919, paying tribute to the work of the Hon. Lady Parsons and Dame Caroline Haslett. He applauded the aim of the Society, which was to encourage and enhance the study of engineering by women, and referred in particular to its interest in training and education matters. In responding to the toast, Miss Leather announced that the membership of the Society was increasing and was now about 300. She also spoke of the importance of training and education and made a plea that industry would show its readiness to accept boy and girl apprentices on the same level. The toast of "The Guests" was proposed by the president-elect, Dr. E. M. Collin, and acknowledged by Mr. F. H. Perkins, M.I.Mech.E., who said that he could see no reason why a woman should not be a good engineer. On Saturday, Miss Leather delivered her presidential address, which dealt with training in and for industry, tracing the developments from apprenticeship controlled by the guilds to the schemes in operation to-day. The concluding item of the conference programme was a discussion on "The Women's Engineering Society and its Future," which was opened by Dame Caroline Haslett.

The Engineering and Marine Exhibition

No. III—(*Continued from page 295, September 7th*)

IN this article we continue our descriptive review of some of the exhibits at the Engineering, Marine and Welding Exhibition which closed at Olympia yesterday.

Hancock and Co. (Engineers), Ltd.

A new dual carriage oxygen profiling machine seen upon the stand of Hancock and Co. (Engineers), Ltd., Progress Way, Croydon, is illustrated in Fig. 25. This machine is fitted with the firm's standard tracer head which incorporates five drives and, with it, cuts can be shaped from wood, strip or metal templates, or directly from a drawing. The electronic drive, described in our articles on the firm's exhibits in the issue of September 2, 1949, can also be fitted.

The flexible coupled burner has provision for cutting bevels in straight lines longitudinally or transversely, and additional burners can be fitted as required. The burners are mounted on a common slide bar extending the whole width of the cutting area. Each burner holder is adjustable by handwheel through a rack and pinion for movement in three directions, vertically, laterally, longitudinally. In this way the burners can be accurately and quickly located without moving the plate or template.

Templates are mounted on a movable template carrier by means of which they can be quickly located in relation to the plate being cut.

In a new method of guiding the tracer by hand, around the outline of a drawing through an optical system, an image in the form of an arrow with centre cross line is projected on to the drawing placed on the tracing table. The tracer wheel does not run over the drawing or the tracing table.

Simple accessories are provided for automatic cutting of straight lengths and circles, whereby, with the help of traverse of the two carriages in conjunction with the use of the template table, simple geometric shapes can be cut automatically without the use of a template. If necessary, the cutting area of the machine can be extended, additional burners can be fitted, or other devices incorporated as required.

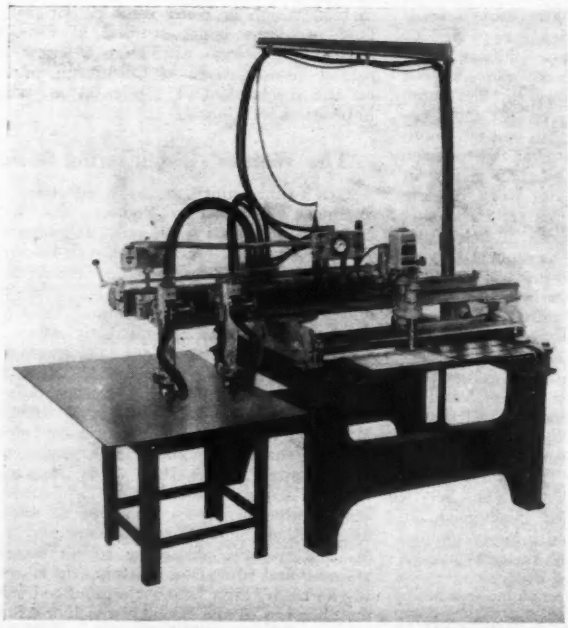


FIG. 25—OXYGEN CUTTING AND PROFILING MACHINE—HANCOCK

Clarke Chapman and Co., Ltd.

When a better performance is required from winches on an a.c. supply than that obtainable from a direct a.c. motor drive, the Ward Leonard group drive exhibited by Clarke, Chapman and Co., Ltd., Gateshead, Co. Durham, offers certain advantages over the individual Ward Leonard drive.

This recent development, which is outlined in the block diagram in Fig. 27, employs a single squirrel-cage motor with a direct-on starter, to drive two dual output d.c. generators with Ward Leonard control, each generator being capable of supplying two winch motors independently and simultaneously. Improved power factor and operating conditions result from the use of a single large induction motor instead of the smaller motors used in the individual Ward Leonard driving motors.

The dual output generator is similar in construction to a normal generator. It has an armature with an orthodox winding and with a single commutator, but there are four brush arms, of which the opposite pairs supply the two output circuits. Similarly, the field system resembles that of the normal four-pole machine, except that each pole carries a compensating coil, besides the excitation coils, to prevent mutual interference between the two outputs. There are also four interpoles, each carrying two coils.

The winch speeds are smoothly variable from creep to full speed, and controlled lowering of the load is given at any intermediate speed. Winch speeds are determined by the generator output voltage which, in turn, is controlled by a potentiometer regulator arranged in the form of a pedestal controller for each winch and placed in any convenient position on the deck. Disc magnetic brakes are incorporated in the winches, but only for use when a halt is called or during a power failure, when braking is applied automatically. No foot brake is provided on these winches since the electric control obviates the need for mechanical braking.

A detailed discussion of the theory of the dual output generator is outside the scope of this article, but an outline of the principle may be useful. Briefly, the basis of the dual output generator is the well-known fact that if, in a two-pole machine, a half pitch (or half chorded), two-pole armature is used, the armature becomes only half effective. Under one half of the main pole arcs the top and bottom layer conductors carry current in the same direction as in a normal machine, but under the other half of the main pole arcs the top and bottom layer conductors carry current in opposite directions. The armature, therefore, has two effective and two neutralised quadrants. If such a two-pole machine is imagined to be a motor then it is evident that the conductors in the neutralised quadrants will not contribute to the torque of this motor, and an analysis of the winding will reveal that the conductors in these neutralised quadrants do not contribute to the total e.m.f across the brushes, as the top and bottom layer conductors in each slot produce e.m.fs. which are equal and oppose each other.

If, in such a machine, the main poles are divided into two parts, only the flux passing through the effective section will have an influence on the voltage between the brushes, whilst the flux of the other section which passes through the neutralised section will have no influence whatever on it. The flux

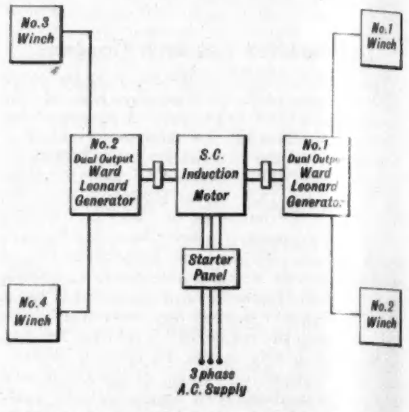


FIG. 27—BLOCK DIAGRAM OF GROUP DRIVE FOR WINCHES—CLARKE, CHAPMAN

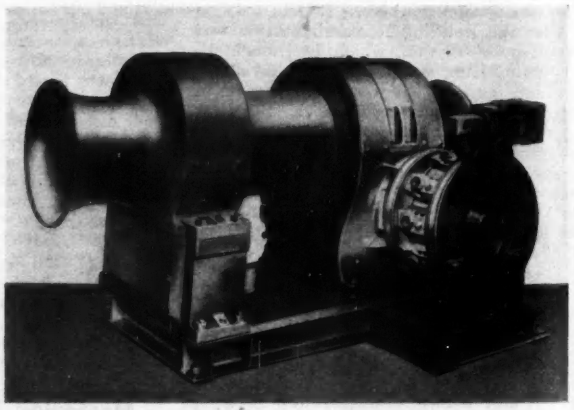


FIG. 26—HYDRAULIC CARGO WINCH—CLARKE, CHAPMAN

passing through the latter sections will, however, set up the voltage in a second set of brushes if they are placed halfway between the first brushes on the same commutator. The voltage across the second set of brushes will not be affected by the flux which gives rise to the voltage across the first set of brushes.

This machine, therefore, resolves itself into two separate circuits, each with its own pair of magnetic poles and pair of brush sets and the two sets have their magnetic axes at right angles.

An important property of the machine described is that current flowing through the first set of brushes will tend to set up a flux in the magnetic axis of the second circuit and would tend to produce a voltage in the second set of brushes proportionally to it. There are a variety of machines which utilise this cross flux and are usually built as

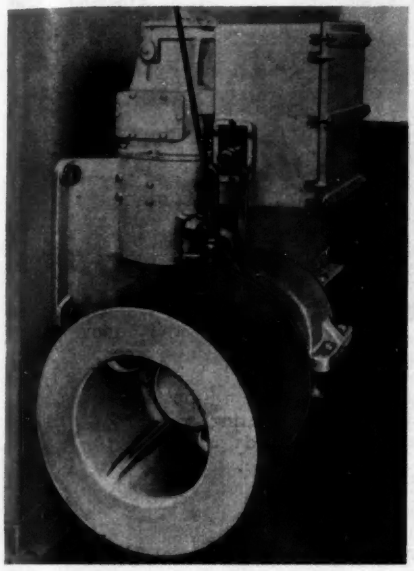


FIG. 28—ELECTRIC TOPPING WINCH —CLARKE, CHAPMAN

exciters or constant current generators and so on. On other machines, the cross flux is suppressed by means of compensating windings; such machines are usually built as motor generators or convertors, and it is to this group that the dual output generator belongs.

The machine is built with four interpoles. While the theory of the commutating is too complex for detailed analysis in this short article, it will be appreciated that, as the conductors in the armature handle the current for two separate circuits, the actual current in the conductors will be either the sum or difference of the output currents, and the interpole windings will have to take this into account. These interpoles, therefore, carry two coils each and are excited cumulatively and differentially on alternate poles.

Another exhibit shown for the first time was a hydraulic cargo winch (Fig. 26), which is intended for duty on board motor coasters and similar short sea traders. Its rated duty is 3 tons at 100ft per minute, 1½ tons at 200ft per minute and light hook at 400ft per minute. Power is provided by a five-cylinder, radial hydraulic pump, driven by either an electric motor or diesel engine and normally housed in the engine-room. The pump body is of simple and robust construction, machined from a solid mild steel ring, into which are machined the bores to take the cylinders, having nitrided steel liners. The inlet and delivery manifolds consist of two annuli machined one in each side of the ring and fitted with cover plates bolted to the body. Inlet valves are placed above the automatic rams and the spring-loaded non-return delivery valves are fitted in the face of the delivery manifold plate.

The nine-cylinder radial motor, machined from a solid steel forging, is directly coupled to the winch worm shaft and has separate cylinder heads bolted to the outer faces of the casing ring. The valves are actuated by tappets in contact with distance plates and parallel roller bearings carried on eccentric rings machined on the crankshaft.

Each prime mover can deliver sufficient high-pressure fluid for operating four 3-ton winches. The pressure line is linked with air-loaded accumulators, which store the hydraulic power when the winches are at a standstill, and the pump will continue to deliver until the accumulators are charged to a pressure of 1600 lb per square inch. Directly this pressure is reached an unloading valve is closed and causes the pump delivery to be returned to the hydraulic oil reservoir and the pump continues to operate under no-load conditions until the winches are again in operation. A fall in pressure to 1500 lb per square inch opens the unloading valve and the pump again delivers to the high-pressure line.

Another exhibit was the electrically driven winch, which we illustrate in Fig. 28. It is suitable for topping ships' derricks, and provides stowage for the loose coils of wire which normally lie on the deck. The winch is of compact and robust design and is self-holding with totally enclosed worm gears running in oil. A simple starter control, having a "dead man" handle is fitted to the water-tight motor and a magnetic brake and self-holding worm stops and holds the derrick in position when the controller handle is in the "off" position or when the current fails. For locking the winch and holding the derrick, when working cargo, a pawl and ratchet are provided, the pawl being electrically interlocked so that, until the pawl is disengaged, the winch will not start lowering. To disengage the pawl the winch is started in the hoisting direction, after which the winch is free to lower.

BRITISH THOMSON-HOUSTON COMPANY, LTD.

On one of its stands the British Thomson-Houston Company, Ltd., showed equipment representative of the company's practice in electric propulsion and auxiliaries for ships. Its other stand was devoted mainly to electronic equipment, including ignitron, thyratron and other control panels for spot and seam welders.

On the first stand there was displayed the alternator of a 600kW auxiliary geared steam turbo-alternator set, which is one of six equipments on order for three new tankers for the British Tanker Company. There will be two turbo-alternator sets per ship and one of the sets is shown (Fig. 29) on test in the B.T.H. Rugby works. For reasons of space the exhibit at Olympia was limited to the alternator alone. It is rated at 600kW, 0·8 p.f., 440V, when running at 1800 r.p.m., corresponding to a frequency of 60 cycles per second. The turbine, which was not exhibited, is a 6000 r.p.m. unit, with combined condenser, designed for operating with steam at 740 deg. Fah. at 420 lb per square inch.

Visitors to the second stand saw the British Thompson-Houston high speed

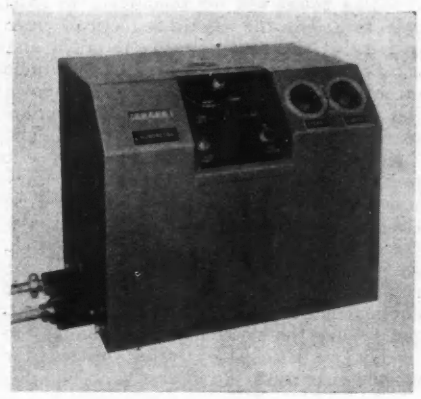


FIG. 30—HIGH SPEED PHOTO-ELECTRIC COUNTER—B.T.H.

electronic counter, which is designed for industrial use and is capable of counting objects at speeds up to 25,000 counts per minute or 1,500,000 per hour. It has a maximum counting capacity (direct reading) of eight digits. On the basis of an eight-hour day, five-day week, and an average of 20,000 counts per minute, this maximum reading would represent about two weeks' working before the counter resets to zero. Provision is made for indicating every fiftieth and hundredth article counted. Normally the counting signal is received from a photo-electric scanning head but any other convenient method of detection can be used, provided that a positive impulse of suitable voltage is applied to the counter. A single-phase, 50 c/s supply voltage of 220/250V is required to operate the counter.

As illustrated in Fig. 30, the counter is housed in a sheet steel case. A sloping panel carries the following four controls: a selector switch marked "auto reset," "manual

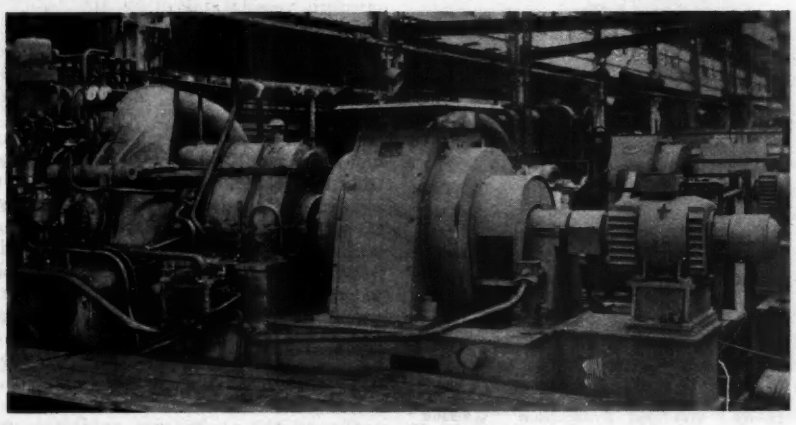


FIG. 29—600KW TURBO-ALTERNATOR SET—B.T.H.

reset," "count" and "test"; a push-button for indexing or resetting, an ejector selection switch and a neon lamp to indicate whether the equipment is operative. Visual indication of the units and tens digits counted is given by two electronic counting tubes to the right of the control panel. A six-figure electromagnetic counter, indicating the count in hundreds, is mounted left of the control panel.

At every fiftieth or hundredth count, according to the position of the ejector switch, the counter closes a set of relay contacts. A batching signal for every 100 counts is given, up to the maximum counting speed. The signal for every fifty counts can be used on speeds up to 18,000 counts per minute. When first switched on the counting tubes will set themselves to indicate zero, but the electromagnetic counter remains at the count already recorded and can be reset to zero manually. To continue on a particular count after a shut-down the counter can be set to the appropriate reading by using the "auto reset" and "manual reset" controls. To show the previously recorded count two indicators, which can be set by hand, are provided for the counting tubes. For testing purposes there is a test position on the selector switch. In this position the counting tubes are subjected to impulses such that the whole equipment from the signal input to the output feeding the electromagnetic counter can readily be checked. During testing the ejector mechanism is inoperative.

The Quasi Arc Company, Ltd.

The arc welding stabiliser "QAS300," exhibited by the Quasi Arc Company, Ltd., Bilston, Staffs, is designed for use with single operator, single-phase arc welding transformers up to a maximum welding current of 300A; it superimposes on the 50 c/s transformer output a high frequency current at approximately 3 Mc/s, which has the effect of improving arc stability. In particular it simplifies arc striking and welding with non-ferrous stainless steel, and other electrodes, which are sometimes difficult to use with welding transformers. Using the stabiliser it is possible to establish an arc without bringing the electrode into contact with the work. The system is, therefore, particularly suitable for starting automatic and semi-automatic welding; it also avoids the risk of pitting alloy steels and stainless steels when starting to weld. The maker states that the stabilising effect upon the a.c. arc is so pronounced that bare wire can be deposited satisfactorily.

Briefly, the "QAS 300" stabiliser embodies a spark-gap oscillator for producing a high-frequency current, which is superimposed on the output of the conventional welding transformer, through the medium of an air-cored transformer. This air-cored transformer increases the efficiency of the high-frequency injection and completely isolates the high voltage low-frequency circuits from the welding circuit. The high-frequency circuit has been designed to improve the duration and, therefore, the effectiveness, of the high-frequency impulses. A small adjusting screw in the front panel of the equipment (Fig. 31) provides means of varying the high-frequency injection.

Switching of the high-frequency current is done through the medium of a 25V relay, supplied from a double-wound auxiliary transformer. Both the relay and the transformer are housed within the "QAS 300" equipment and they can be connected by a two-core T.R.S. cable to the foot switch or other remote switch, whereby the operator can switch the equipment on or off. When remote control is not required, the two remote control terminals on the welding machine are connected together and use is made of the rotary switch on the front panel. A filter circuit, approved by the G.P.O., is incorporated to prevent high-frequency feedback into the supply mains. Three fuses mounted inside the case protect the high voltage transformer, the relay and the filter circuit.

FIG. 31—ARC WELDING STABILISER "QAS300"—QUASI ARC

On another stand the Quasi Arc Company arranged an interesting demonstration of a complete range of "Unionmelt" submerged arc automatic welding equipment, including some apparatus that is new to this country.

The "Unionmelt" process, which is widely used for the welding of Class 1 pressure vessels and other applications, is a method of submerged arc welding in which molten metal from a continuous wire electrode is deposited on the parent metal through a covering of slag-forming powder. The electrode is a bare wire, which is fed automatically into the melt at a rate determined by a voltage control unit, which controls the feed mechanism so that the wire is advanced at the correct rate to maintain a constant arc length. During welding and cooling the molten metal is cleansed of impurities and shielded from the atmosphere to produce weld metal with good mechanical properties. Heavy welding currents, automatic control of welding conditions and exclusion of the atmosphere from the welding zone are the main characteristics of the "Unionmelt" process.

One of the equipments exhibited was a "D.S.-F" flexible welder (Fig. 33), capable of operating at welding currents up to 900A. In this equipment the welding wire and the "Unionmelt" flux are fed simultaneously down a 20ft flexible tube to a small nozzle held by the welding operator. Air pressure automatically feeds the "Unionmelt" powder around the wire and when a sufficient covering of powder has been deposited, the operator starts welding by touching the wire on the workpiece. When the welding current begins the operator merely has to guide the nozzle along the joint or over the area to be welded, holding the nozzle at a reasonably uniform distance above the weld: the correct arc length is maintained by the automatic voltage control.

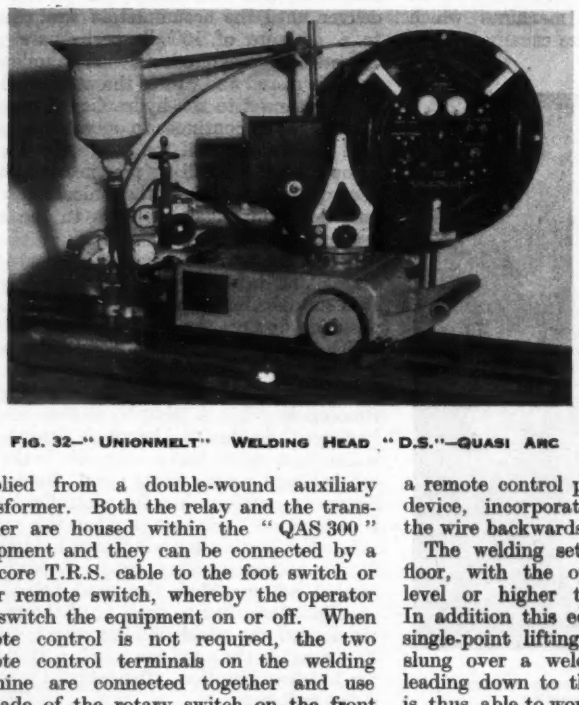


FIG. 32—"UNIONMELT" WELDING HEAD "D.S."—QUASI ARC

The "D.S.-F." welding set is portable and the tank on the equipment contains 75 lb of "Unionmelt" flux, which is fed as required down the flexible hose, to provide enough flux for a day's work. A 25 lb coil of $^{3}/_{32}$in or $\frac{1}{8}$in dia. wire is mounted on the set, as shown in Fig. 33 and is automatically fed along the hose at the required rate to maintain constant arc length. To allow the welding operator to control the process without moving from his workpiece, the set is provided with a remote control push-button start and stop device, incorporating a switch for inching the wire backwards or forwards in the hose.

The welding set can stand on the shop floor, with the operator welding at floor level or higher than the machine itself. In addition this equipment is fitted with a single-point lifting eye, so that it can be slung over a welding area with the hose leading down to the welding operator, who is, thus, able to work freely within a radius of 15ft to 20ft. Alternatively, the plant can

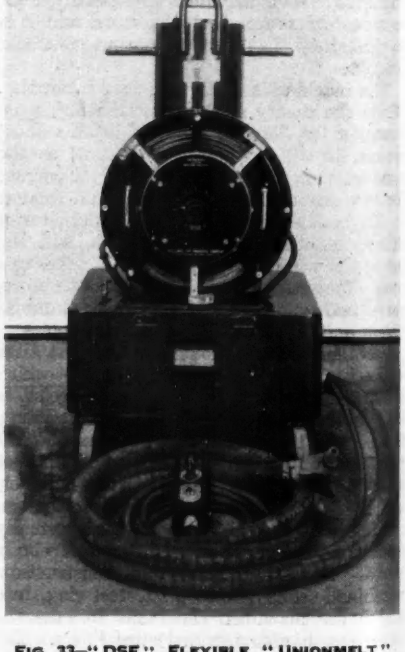


FIG. 33—"DSF" FLEXIBLE "UNIONMELT" WELDER—QUASI ARC

be suspended from a wall-mounted jib crane, thus enabling the welder to operate freely in a wider area covered by the radius of the jib.

Another "Unionmelt" exhibit that was seen on the same stand is the "D.S." welding head. It has a maximum current capacity of 1200A, can feed wire from $^{3}/_{32}$in to $\frac{1}{4}$in dia., and can make one-pass butt welds in material from 16 gauge to $\frac{3}{4}$in thick. The welding head (Fig. 32) is mounted on a self-propelled carriage provided with stepless speed control, forward and reverse. Handwheels, which can be seen to the right of the flux hopper, provide for vertical adjustment of the welding head through $2\frac{3}{8}$in and horizontal adjustment through $1\frac{1}{8}$in. At the same time the head can be rotated through 360 degrees about the main support, which is mounted on the travelling carriage. The reel holds a 25 lb coil of wire and, as in the "D.S.-F." equipment, carries the voltage control unit, which can be readily removed. A flexible attachment, 20ft long, can be connected to the "D.S." head, for manual operation, the flux being fed by gravity from a small hopper at the nozzle end of the flexible hose. A small relay is fitted to enable welding to be started by touching the wire on the workpiece. The maximum size of wire which can be fed through this attachment is $\frac{1}{8}$in dia. and, to enable currents up to 800A to be used with this wire, a triple speed gear drive is supplied with the unit.

Mirrlees, Bickerton and Day, Ltd.

On the ABOE stand, Mirrlees, Bickerton and Day, Ltd., of Stockport, showed an example of the new "J.V.S.S. 16" diesel engine (Fig. 34) which has sixteen cylinders in vee form, and is high-pressure turbo-charged. It is designed for marine, industrial, rail traction and oil field duties. The engine has a bore and stroke of $9\frac{3}{4}$in and $10\frac{1}{2}$in respectively, and develops 2270 b.h.p. at 900 r.p.m., the b.m.e.p. being 160 lb per square inch and the boost pressure 7·5 lb per square inch.

The bed-plate and the monobloc cylinder housing are fabricated from mild steel plate, the welds being stress relieved. An injector

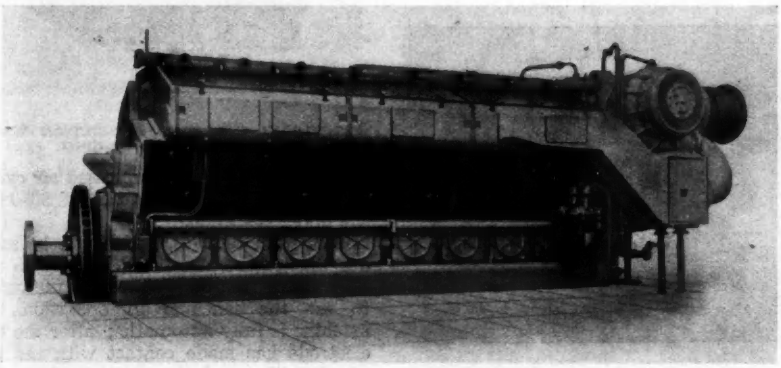


FIG. 34—2270 B.H.P. DIESEL ENGINE—MIRRLESS BICKERTON AND DAY

is placed centrally between the two exhaust and two inlet valves, which are incorporated in the cast iron cylinder head, and there is also a starting non-return valve. The cylinder liners, which are of cast iron and chrome-hardened, are held firmly in the cylinder head and are free to expand downwards. The pistons are of aluminium alloy and have four compression and two scraper rings and a combustion chamber machined in the crown. The connecting-rod is an H-section hardened and tempered steel forging, the small-end bearing being pressure lubricated from the big-end, and the crankshaft is a 45/50-ton steel forging hardened and tempered. Valve actuation is by push rods from chill cast cams carried on high-tensile steel ground bar camshafts, the valve-operating gear being pressure lubricated and totally enclosed. Oil fuel is delivered to each cylinder by individual pumps and starting is by compressed air delivered at a pressure of about 300 lb per square inch.

Castings, Forgings and Metals

The manufacturers of ferrous and non-ferrous metals and alloys and the makers of forgings and castings were well represented at the exhibition and, although their products were probably less spectacular than the engines, plant and equipment, visitors have found many of the exhibits interesting and well worth close inspection.

Upon the stand of Langley Alloys, Ltd., of Slough, the wide range of products displayed included copper base alloy castings, stampings, forgings and bar; nickel alloy castings; stainless steel castings; resistance welding electrodes; and nickel alloy, stainless steel and bronze valves for use in handling corrosive liquids. Exhibits of interest to the general and marine engineering industry shown included products in the firm's "Hidurax" range of aluminium bronzes and "Hidurit" manganese bronzes in the form of stampings, castings and rolled bar. For use in the chemical and process fields where the nickel alloys and stainless steels are of special interest there were shown castings in Monel, nickel, Iconel, nickel-base alloys, and different grades of stainless steel. The finished products upon this stand included a range of chemical valves and fittings in nickel alloys and stainless steels.

The products of the subsidiary and associated firms in the United Steel Companies, Ltd., were shown upon one stand. These products vary from steel strip, 0·001in thick, to slabs up to 17in thick, with intervening sizes and sections in a multiplicity of qualities, as well as refined irons for foundry purposes.

The use of powder metallurgy has been steadily growing in industry, and visitors found much of interest in the display of components produced by the "Dueram" process upon the stand of Dualloys, Ltd., 108, Park Street, London, W.1. This display showed how, starting with powdered metals, such as iron, copper, tungsten, &c., die-pressed components can be produced economically to very close limits and with controllable porosity. A section of the firm's stand was also devoted to bearings and bearing metals.

An exhibit which attracted a great deal of interest was a finished cast steel back-up roll for the broadside stand of a hot strip mill, on the stand of the Darlington Forge, Ltd. This roll is 20ft 10in long, the barrel being 10ft 10in long by 4ft 6in diameter. With a weight of 47 tons, this is stated to be one of the heaviest rolls of its type made in this country. Also to be seen towering above other exhibits was a forged steel rudder stock, 18ft high, weighing 7 tons, and other units displayed included a 9½-ton propeller shaft, 19ft long, and a 6½-ton diesel engine crank journal.

For more than sixty years the forge has been producing structural steel castings and forgings for ship construction, and in that period has served "Queen Mary," "Mauretania I" and Mauretania II," "Nelson," "King George V," "Prince of Wales," "Ark Royal," "Orcades," "Himalaya," "Rangitoto," "Chusan," and many others. A scale model of the "Mauretania" castings and forgings showed how these components are incorporated in the ship's structure.

The A.P.V. Company, Ltd., of Wandsworth Park, London, the manufacturers of plant for the dairy, brewery, food and chemical industries, exhibited castings in aluminium, gunmetal and stainless steel. A prominent part of the display was taken up by "A.P.V.-Cooper" stainless steel gate valves and stainless steel sanitary pipe fittings.

Gravity and low-pressure aluminium die castings, which weigh from a few ounces up to 20 lb and for a wide range of applications, were shown by the Non-Ferrous Die Casting Company, Ltd., of North Circular Road, London, N.W.2, together with castings manufactured in free-cutting lead-brass material.

Together with representative types of its tipped and solid tools, Deloro Stellite, Ltd., Highlands Road, Shirley, Birmingham, showed examples of "Stellite"-faced work, such as valves for diesel and high-pressure, high-temperature steam and castings, including turbine erosion shields and diffuser blades.

Frequent demonstrations were given of "Stellite" facing of production components by the oxy-acetylene method, and any visitors who were interested could have small parts faced for testing purposes.

J. Brockhouse and Co., Ltd., of West Bromwich, and its associated companies exhibited items from a diverse range of engineering products, including drop forgings weighing from a few ounces up to 150 lb, iron castings up to 2 tons, steel castings up to 6 tons, pressure and gravity light alloy die castings, cold-rolled sections, &c.

Soft soldering materials in all forms were shown by Fry's Metal Foundries, Ltd., of Merton Abbey, London, S.W.19, and demonstrations were given with many of the firm's well-known products. Particular emphasis was laid on the uses of "Fryolux" solder paint, and a number of specimens of articles soldered with this material were displayed to show the combination of strength with economy which can be obtained with its use.

Together with an interesting display of plate, sheet, strip, tube, wire and rod in copper and copper-base alloys, and aluminium and aluminium alloys, Imperial Chemical Industries, Ltd., Metals Division, of Witton, Birmingham, showed a large range of its alloy fittings and materials for special applications.

Meehanite high-duty cast iron was used in the construction of components for a very large number of the exhibits at Olympia, and on the stand of the International Meehanite Metal Company, Ltd., of 66, Victoria Street, London, S.W.1, groups of castings, photo-

graphs, test samples, &c., showed the many uses of the metal in modern plant and equipment. This exhibit has been arranged particularly by the British licensees of the process, which supply castings to the trade.

Pumping Equipment

In addition to the pumping equipment described under the names of individual firms elsewhere in these articles, a number of other companies showed a wide range of pumps for various duties. Many of these pumps are generally familiar, although in several cases the makers have extended the range and introduced new models.

On the stand of Gwynnes Pumps, Ltd., of Hammersmith, London, W.6, three impellers were exhibited to illustrate the difference between axial flow, mixed flow and centrifugal designs.

Fig. 35—12-Stage Horizontal Split Casing Pump—Gwynnes

The axial-flow impeller will ultimately be used in a 24in pump driven by an 85 h.p. diesel engine, and is for irrigation purposes in Gambia. This pump will discharge 10,000 g.p.m. against 15ft total head. The mixed-flow impeller is for a 36in pump driven by a 300 h.p. motor and will discharge 26,000 gallons of sea water per minute against a total head of 27ft. The centrifugal pump impeller is for one of eight sets of 45in vertical-spindle pumps which are being supplied to the British Electricity Authority for circulating cooling water at the Uskmouth power station. These units are capable of a duty of 45,000 gallons of water per minute against a total head of 60ft, and are each driven by 1100 h.p. motors with grid-controlled rectifiers to give speed variation.

A 24in twelve-stage pump manufactured for the British Railways, Southern Region, for the hydraulic pumping plant at Deptford Wharf was also shown. This horizontal, split-casing pump, constructed in cast steel which is designed for a working pressure of 750 lb per square inch, is illustrated in Fig. 35.

Amongst several of its rotary self-priming pumps, Mono Pumps, Ltd., 67, Clerkenwell Road, London, E.C.1, showed one engaged on pumping dirty oil-laden water as typical of a ship's bilge water. The makers also arranged a representation of the new Mono pump automatic water pressure system for fresh water and sanitary supplies, which has been devised to provide an easily installed unit which does not need a source of compressed air to "top" up the pressure tank.

The Saunders Valve Company, Ltd., of Cwmbran, Mon., showed, together with its valves, two 1½/2in "Safran" pump units. Each of these units is driven by a ½ h.p. motor running at 1430 r.p.m., and is designed to deliver 2280 gallons per hour at 10ft head. A number of other small pumps for various drives and different duties are also exhibited by the company.

Together with its rotary hydraulic pumps and motors, which have capacities ranging from 2 to 40 cubic inches per revolution with pressure outputs of up to 1500 lb per square inch, Keelavite Rotary Pumps and Motors, Ltd., of Coventry, showed a number of high and low-pressure gear pumps. These high-pressure pumps incorporate the firm's hydraulic axial balancing system and are built with capacities ranging from 0·44 cubic inches to 5·6 cubic inches per revolution at 2240 lb per square inch.

The design of the self-priming pump developed by Megator Pumps and Compressors, Ltd., 43, Berkeley Square, London, W.1, and the principle upon which it operates, was described in our issue of March 7, 1947. These simple self-priming pumps have a high suction lift, and low fluid velocity enables them to deal with thick and viscous liquids. An inherent characteristic of the design is that wear is automatically taken up.

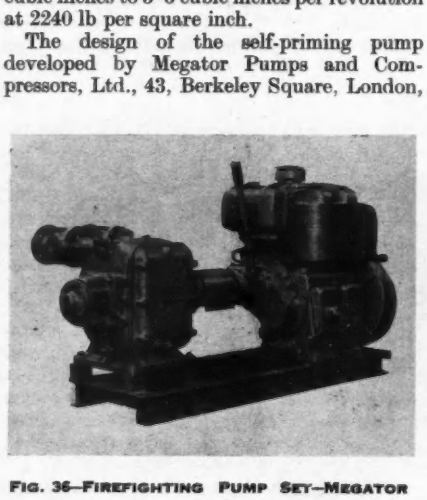


Fig. 36—Firefighting Pump Set—Megator

A demonstration "Megator" pump, type M, was shown in operation mounted on a tank to illustrate how it primes itself, and can operate on "snore." A self-contained marine pressure set is designed for use on fresh or sea water systems. It was used to demonstrate the pump's ability to act as either a pump or a compressor. One of the firm's diesel engine driven pumps for fire-fighting and general service is illustrated in Fig. 36. This unit is designed to Lloyd's requirements and B.O.T. regulations. It embodies a high suction lift with self-priming and handles two ½in nozzles throwing two 40ft jets.

Siemens-Schuckert (Great Britain), Ltd.

The welding machines exhibited by Siemens-Schuckert (Great Britain), Ltd., Brentford, Middlesex, include an air-operated projection welder which can weld up to nine spots simultaneously depending on the gauge of the mild steel sheet.

As illustrated in Fig. 37, the welding arms are provided with two 10in square slotted platens for clamping down the special welding fixtures that may be required for each individual job. The lower platen can be raised or lowered through a travel of 10in, giving great flexibility in the size of jigs which can be accommodated in the available space. Welding pressure is derived from a 7in diameter compressed air cylinder which provides a total force of 3000 lb on the upper electrode.

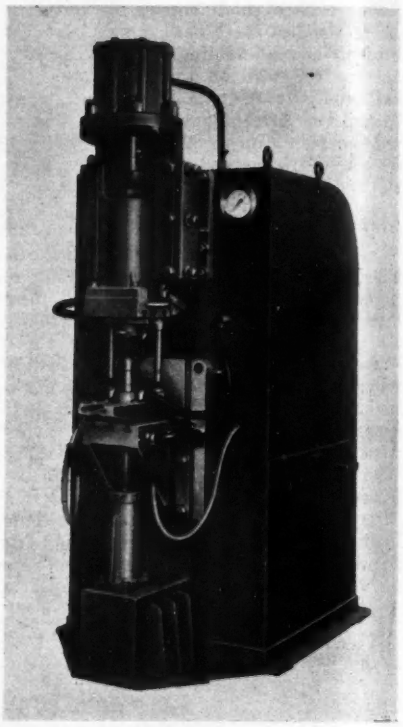


Fig. 37—Air Operated Projection Welder —Siemens Schuckert

Two push buttons, which can be seen in our illustration, are fitted. Being in series they have to be pressed simultaneously to set the machine in operation. The machine is fully automatic; after the upper electrode has made contact with the work, whether the push buttons continue to be depressed or are released, the machine will continue to follow its predetermined programme which includes electronic control of welding time and forge time. The dwell time after welding can be adjusted independently of the welding time. The resistance welding transformer incorporated in the machine has a nominal welding capacity of 100kVA, with a diversity factor of 15 per cent, and is operated by a high-speed contactor, which has heavy contacts to make the machine suitable for operation on a production basis.

(*To be continued*)

Time Study on Cranes at Rail Bank, Workington

By A. W. SWAN, B.A., B.Sc., A.M.I.Mech.E.

THIS time-study is part of an operational research study on the rail bank at Workington. The rail bank is the yard to which rails emerge from straightening and drilling and ending, the last processes, and in which they are sorted, examined by the inspectors of the British Railways, &c., loaded on to railway wagons and dispatched. There have been difficulties in getting away sufficient tonnages of rails and the general problems of crane usage, inspection and loading were to be considered.

Preliminary Discussions

The first stage in dealing with the general problem was, as is customary for the writer, to make himself as well acquainted as possible with the techniques and problems involved and therefore to talk to, or rather to ask questions and listen to, the men responsible for carrying on the work; in this case the general works manager, who put the problem; the steelworks manager and the rail bank manager. From these discussions the general method of working the rail bank was made plain, together with ideas held by those closely concerned with the job as to why dispatch tonnages are sometimes not up to requirements. It became clear from these discussions and from examination of the regular works day-to-day information that the overruling factor was the supply of wagons for loading rails by British Railways, and it was evident that there was no point in making studies of crane usage, &c., until a regular and adequate supply of railway wagons was forthcoming. The management were already well aware of this position and strong representations were being made to British Railways. This demand produced results in a steadier flow of the right number of the right kind of wagons, and tonnages dispatched improved to the stage where they equalled or were greater than the daily output of rails and the large stock of rails ready for dispatch began to drop.

When an adequate number of railway wagons was being received at the proper daily rate or approximately so, it was no longer possible to blame all delays on the rail bank on the wagon position, and a study of the sorting, loading and inspecting on the bank was possible. This resolved itself into a time study of the cranes, since the crane movements reflected all the general conditions.

Arrangements for Time Study

As at Workington there is no regular time-study department, it was necessary to make special arrangements. Three young men in various departments, who had been previously borrowed for time-study on the mills and had been trained in the use of decimal-minute stop-watch and techniques of time-study for that purpose, were borrowed again for a time-study on three cranes. Three men only, one per crane, were necessary, as the rail bank, apart from having a certain amount of sorting of rails to be done at night, works normally on a single day shift because inspection of rails for surface defects is only considered to be satisfactory in daylight.

The cranes were No. 4, which takes the rails as they emerge from drilling and ending, and Nos. 1 and 2, to which they are fed by roller rack from the bay under No. 4 crane, and which serve final inspection by the railway inspectors and loading on railway wagons (see Fig. 1).

No. 4 crane works normally on a short, closed cycle of from three to five minutes. It loads four or five rails at a time, as they emerge from drilling and ending, according to the size being rolled, carries them either part length of the gantry (short rails) or the complete distance (full length rails), unloads and returns. Cranes Nos. 1 and 2 have a greater variety of work, clearing the roller rack of accumulations of rails from No. 4 crane, laying out rails for inspection, sorting, stacking and loading. Each activity may occupy from one to forty minutes or more. The Tippett snap-reading method of time-study, which has been found very useful in conditions which have a certain similarity to those which were to be studied, was considered, but since only a small number of cranes were to be studied it was decided to make complete time-studies of the ordinary type. All the time-study men were placed temporarily under the supervision of the development engineer (one was his assistant).

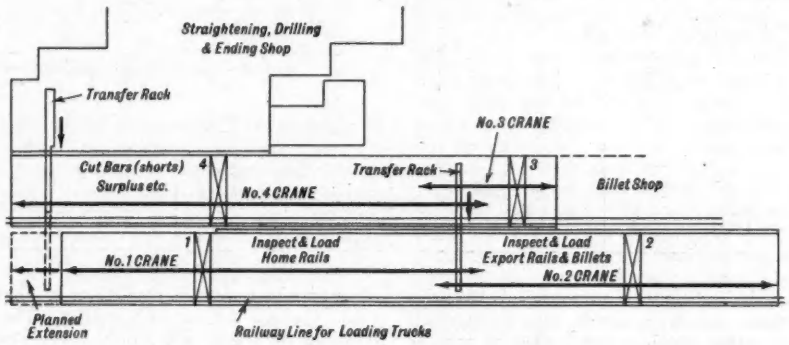


FIG. 1—LAY-OUT AT THE RAIL BANK

Instructions were given for the time-studies to be continuous, the times to be assigned under definite headings, and to be accompanied by notes on unusual events and on all idle times and delays. The headings for No. 4 crane were: load, travel, unload, return, idle, wait for drilling and ending, delays (breakdowns, &c.), other services. The final heading was used because crane No. 4 is occasionally taken from its usual work of moving rails and serves the cold saw. The study was for two weeks, one week on 95 lb bull-head rails, one on 109 lb flat-bottom rails. There are various differences between the two rails from the point of view of crane usage. The 95 lb rails are lifted five at a time, whereas the 109 lb rails are lifted four at a time and as both types of rail take approximately the same time to "drill and end," the normal cycle of emergence from drilling and ending is naturally longer for five 95 lb rails than for four 109 lb rails. Again, the bull-head and flat-bottom rails call for different techniques in arranging for a lift by the magnet crane. It was expected that there would be differences in time-study results for the two types of rail.

For cranes Nos. 1 and 2 the headings were: clear rack (remove accumulation of rails); move (sort, lay out for inspection, &c.); load (on to railway wagons); idle (no work); and delay (breakdown, &c.). The study for these cranes was for two weeks continuously, then for another two weeks a month later.

Analysis of Time-Study Results

When the time-studies were complete the question arose as to how to analyse the results.

It has been the general practice in time-study work either to consider the study as indicating the shortest possible times and, hence, to concentrate the attention on, say, the shortest 20 per cent, the shortest 30 per cent or to consider the study as giving a picture of current operation and to concentrate on the average. In both cases it has been customary either to neglect times which are considered to be "abnormally" long or to examine these individually.

There are several very serious pitfalls in the above methods. It is, for instance, very difficult to define satisfactorily what are the "shortest" times and what are "abnormally" long times. The more up-to-date and more realist method, which is free from this and other difficulties, is to examine all data on the basis that most industrial processes show persistence, and that all the times recorded, including the very short and the very long, are typical of practice as it stands, forming a family having its own definite characteristics.

A simple method of examining the data from this point of view is to set out all the times in the form of distributions, that is, taking as an example, the loading of crane No. 4 to tabulate the number of occasions on which the crane was timed as taking 0·1, 0·2, 0·3, 1·1, 1·2, 1·3, &c., minutes to load. The advantages of the method will appear from examination of some of the data for crane No. 4 (see Tables I, II and III). Most of the conclusions set down in the report issued to Workington on the time-study were drawn in the same manner but the method and basis of the conclusions are not given in detail in the report as in the following examples:

Crane No. 4, Load and Unload.—(1) Each of the distributions (95 lb rail and 109 lb rail) has a single peak, indicating a reasonable uniformity of practice.

(2) The bases of the distributions are fairly wide and at least 10 per cent of the values are long times reaching up to quite high single times. This indicates that there are frequent occurrences of a common difficulty and that serious difficulty occurs in at least 10 per cent of the loadings. This difficulty should be looked into and removed if possible. If they are removed, the resulting distributions will:—

(*a*) Be narrow and free from tails, indicating greater uniformity of practice.

(*b*) Have their average at a shorter time, indicating better practice.

Crane No. 4, Travel.—(1) There are two

TABLE I.—*Crane No. 4 : One Week on 95 lb Rail, One Week on 109 lb Rail*

Load				Unload			
95 lb		109 lb		95 lb		109 lb	
Minutes		Minutes		Minutes		Minutes	
—	—	0·3	4	—	—	0·3	2
—	—	0·4	15	0·4	4	0·4	8
0·5	3	0·5	14	0·5	12	0·5	32
0·6	2	0·6	11	0·6	19	0·6	34
0·7	11	0·7	7	0·7	12	0·7	34
0·8	19	0·8	9	0·8	13	0·8	40
0·9	22	0·9	7	0·9	10	0·9	29
1·0	19	1·0	18	1·0	24	1·0	30
1·1	30	1·1	21	1·1	18	1·1	24
1·2	10	1·2	24	1·2	16	1·2	19
1·3	22	1·3	19	1·3	7	1·3	6
1·4	24	1·4	30	1·4	15	1·4	6
1·5	12	1·5	33	1·5	8	1·5	6
1·6	6	1·6	26	1·6	11	1·6	2
1·7	6	1·7	9	1·7	8	1·7	2
1·8	2	1·8	12	1·8	3	1·8	3
1·9	5	1·9	3	1·9	2	1·9	1
2·0	0	2·0	8	2·0	1	2·0	1
2·1	0	2·1	3	2·1	0	2·1	3
2·2	2	2·2	1	2·2	1	2·2	2
2·3	0	2·3	4	2·3	2	2·3	1
2·4	0	2·4	1	2·4	1	2·4	1
2·5	0	2·5	0	2·5	1	2·5	1
2·6	1	2·6	1	2·6	2	2·6	0
—	—	2·7	0	2·7	2	2·7	1
—	—	2·8	2	—	—	2·8	1
4·8	1	2·9	0	3·2	7	—	—
—	—	3·0	2	—	—	—	—
8·6	1	—	—	3·5	1	4·1	2
—	—	3·3	1	—	—	—	—
—	—	—	—	4·0	1	4·5	2
—	—	3·5	1	—	—	—	—
—	—	—	—	4·5	1	5·0	1
—	—	4·2	1	—	—	—	—
—	—	5·0	2	—	—	—	—
—	—	6·0	1	—	—	—	—
—	—	6·1	1	—	—	—	—
—	—	6·3	1	—	—	—	—
—	—	6·7	1	—	—	—	—
—	—	6·8	1	—	—	—	—
—	—	8·5	1	—	—	—	—
—	—	9·3	1	—	—	—	—
2429/198		4305/296		2353/197		2880/294	
Average 1·227		1·454		1·194		0·98	

peaks, indicating the presence of two distributions, one with a wide base for cut bars (short rails), which are unloaded at various points along the crane travel; one with a narrow base for full-length rails, all of which are carried the full distance of the gantry.

TABLE II.—*Crane No. 4.—Travel*

	95 lb rail, one week		109 lb rail, one week	
	Minutes		Minutes	
Cut bars	0·2	4	—	—
	0·3	12	0·3	5
	0·4	2	0·4	9
	0·5	1	0·5	12
	0·6	5	0·6	14
	0·7	32	0·7	27
	0·8	10	0·8	11
Rails	0·9	0	0·9	5
	1·0	23	1·0	52
	1·1	70	1·1	100
	1·2	23	1·2	34
	1·3	2	1·3	8
	1·4	0	1·4	2
	1·5	1	1·5	1
	1·6	0	1·6	0
	1·7	0	1·7	0
	1·8	1	1·8	2
	1·9	0	1·9	1
	2·0	0	2·0	2
	2·1	1	2·1	1
	2·2	1	2·2	1
	2·3	0	2·3	0
	2·4	1	2·4	4
	2·5	2	2·5	4
	2·8	1	—	—
	3·1	1	—	—
	3·2	1	—	—
	3·6	1	—	—
	3·7	1	—	—
	3·8	1	—	—
	1922/186		3026/295	
	Average 1·033		1·026	

(2) There are fairly long tails with high individual times and these call for investigation.

Crane No. 4, Idle, Waiting for Drilling and Ending.—(1) The distributions are "square," that is, there are no special peaks or concentrations. This means non-uniformity; in other words, unsettled conditions at the previous process, drilling and ending. The distribution for 109 lb rails is on the whole placed lower down, shorter times, than that for 95 lb rails. This is to be expected, since, as explained above, the crane waits for five 95 lb rails from drilling and engine before moving.

(2) The distributions for both 95 lb and 109 lb rails have long tails, reaching up to high individual waiting times of twelve and fifteen minutes. This evidence reinforces that of (1) that conditions in drilling and ending are unsettled.

FURTHER ANALYSIS

The distribution form of analysis measurements throws a new light on the practical value that can be attached to the "best" and "worst" percentages.

(*a*) If the distribution is symmetrical or nearly so, with a single peak (as in crane No. 4, unload 109 lb rails), the average best and worst percentages have a practical meaning.

(*b*) If most of the distribution is symmetrical but there is a long tail at the upper end (as in crane No. 4, load 109 lb rails), the average is pushed up unduly and is misleading.

(*c*) If there are two peaks (as in crane No. 4, travel), the meaning is that there are two distributions and therefore two independent sets of conditions. These should be analysed separately, since a single analysis would be misleading.

(*d*) If the distribution is "square" (as in crane No. 4, idle, 95 lb and 109 lb rails) the "average," "best" and "worst" percentages have little or no practical meaning and the extent of the "squareness" is the important information.

Distributions do not provide information on the sequence of events, which may be important, as indicating the general pattern of the work. Crane No. 4 works on a definite closed cycle of short duration and there were no special questions in regard to its sequence of events. In connection with cranes Nos. 1 and 2, however, handling rails for inspection and loading, there are a number of questions which only an "order of events" sequence can answer. Charts of this type in simple bar form were constructed, one per week per crane (Figs. 2 and 3). The bar charts were studied to gain visual impressions on the following points:—

(1) Is there a regular sequence as among: clear rack, move, load, and idle, and if so, what is it? (Delays are considered as accidental and do not come, therefore, into any ordinary sequence.)

(2) Are there typical times for clear rack, move, load, and idle and, if so, what are they? (Deductions on this point should check with those made from the distributions.)

(3) Is there any special day of the week effect: is, for instance, the beginning of the week more free from idle periods than the end of the week?

(4) Is there any special time-of-day effect? Is there, for instance, more loading in the afternoons than in the mornings?

It is not proposed to set out in this paper all the conclusions that were drawn from the "order of events" charts, but some may be

TABLE III.—*Crane No. 4.—Idle*

95 lb rail, one week			109 lb. rail, one week		
Minutes	D/E	Not D/E	Minutes	D/E	Not D/E
0·1 to 0·5	1	0	0·1 to 0·5	1	0
0·6 to 1·0	0	0	0·6 to 1·0	12	1
1·1 to 1·5	6	0	1·1 to 1·5	12	0
1·6 to 2·0	8	0	1·6 to 2·0	19	2
2·1 to 2·5	7	2	2·1 to 2·5	15	2
2·6 to 3·0	11	0	2·6 to 3·0	19	4
3·1 to 3·5	9	1	3·1 to 3·5	19	0
3·6 to 4·0	6	0	3·6 to 4·0	9	3
4·1 to 4·5	7	0	4·1 to 4·5	5	3
4·6 to 5·0	14	0	4·6 to 5·0	2	1
5·1 to 5·5	14	1	5·1 to 5·5	4	2
5·6 to 6·0	4	1	5·6 to 6·0	1	0
6·1 to 6·5	15	1	6·1 to 6·5	5	2
6·6 to 7·0	6	0	6·6 to 7·0	4	2
7·1 to 7·5	11	2	7·1 to 7·5	1	3
7·6 to 8·0	3	—	7·6 to 8·0	0	—
8·1 to 8·5	3	—	8·1 to 8·5	0	—
8·6 to 9·0	3	—	8·6 to 9·0	1	—
9·1 to 9·5	3	—	9·1 to 9·5	1	—
10·8	1	—	9·6	—	—
12·6	1	—	9·7	—	—
12·8	1	—	9·8	—	—
14·8	1	—	9·9	—	—
15·0	1	—	12·0	1	—
17·0	1	—	14·5	1	—
—	—	—	45·0	1	—
718·9/137	40·0/8		464·7/134	108·3/25	
Average 5·25	5·0		Average 3·47	4·33	

mentioned. It was observed, for instance, that crane No. 1 apparently had a higher proportion of idle times in the mornings, between 9 a.m. and 11 a.m. than during the rest of the day. The difference between the 9 a.m. to 11 a.m. period and the rest of the day was tested statistically and found to be real, not merely an accident resulting from a small sample of results.

Another impression of practical importance, which was proved to be significantly correct, was that the total time can be considered as being divided into two separate groups, clear rack+move+delays and load+idle. The close relationship of load and idle was particularly striking; a reduction in idle time being always accompanied by a gain in loading time and vice versa.

The practical meaning is that if we accept the condition that the proportion of total time taken by clear rack + move + delays cannot be altered appreciably, then the remaining period of time load+idle is the one we must examine more closely, if the proportion allotted to loading is to be increased. In other words, idle time must be reduced by providing a better flow of inspected rails ready for loading.

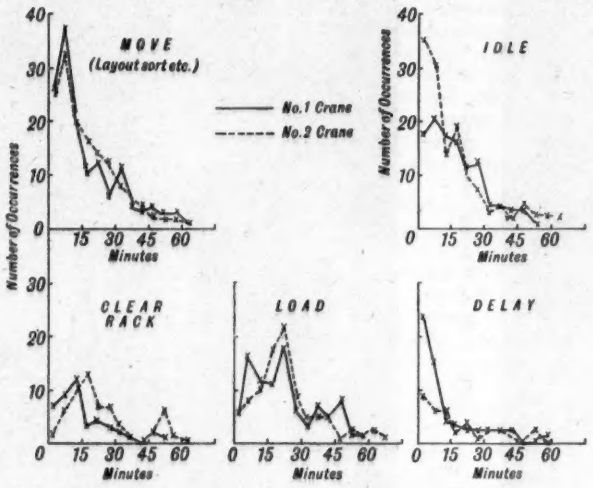


FIG. 3—ANALYSIS OF "ORDER OF EVENTS" CHART

MAIN CONCLUSIONS FROM THE TIME-STUDY RESULTS

The above deductions made from the distributions of the time-study results and the "order of events" charts form only part of a comprehensive set. The overall conclusions are that all three cranes are on top of their jobs as they stand at present, but that further investigations on specified points of technical practice should lead to improvements, which would speed up loading for crane No. 4 and reduce its idle time and reduce idle times for cranes Nos. 1 and 2. These steps would allow for increased overall tonnages to be handled in the future with existing crane equipment.

GENERAL CONSIDERATIONS

The investigation on the rail bank illustrates a number of important conditions, all of which must obtain before an operational research job can be a success.

(1) The management was in full agreement that the investigation should be undertaken.

(2) The management realised that the investigation was a major job and allowed time to the investigators to carry on the preliminary discussion, do the necessary hard thinking, make the complex arrangements for the time-study, arrange preliminary trials, &c., and, finally, carry out the tabulation and examination of the time-study results.

(3) All concerned with the rail bank accepted the operational research workers' good faith that they would produce information which would be constructive and not merely critical. The general feeling was: "the rail bank is doing a good job, perhaps it can do better and what can you do to help us?" The result was a full supply of information without quibble, a full disclosure of points of view on working conditions and complete co-operation during the time-study and the analysis of its results.

(4) The actual time-studies were made by Workington technical men, working under a Workington departmental executive. Full advantage was thus taken of local knowledge and of local loyalty.

(5) The methods used in the examination of the results were as simple as possible, more complex methods being applied only when the simpler methods did not yield sufficient or sufficiently precise information. The general idea was to apply the statistical point of view, and since the simplest statistical method is to set out results as distributions and draw as many visual deductions as possible, this was the first step. It was found that this procedure yielded a large amount of valuable information and that more complex statistical techniques were seldom required.

It was realised that the distributions were useless from the point of view of sequence of events and it was necessary therefore to supplement the distributions by chronological charts. The impressions from these charts were checked arithmetically and tested by rigorous statistical techniques.

(6) There was the minimum of correspondence. Points to be cleared up were discussed in personal discussion during the frequent visits of the operational research workers from Sheffield to Workington.

(7) All the results were discussed in draft with the general works manager and the rail bank manager. The rail bank manager felt that there was not the spare capacity for the cranes that was shown by the report to exist, but he considered that it was a fair document, written in a constructive spirit.

(8) The report is written in standard English, using only those statistical expressions which are now familiar to steelworks technicians, and giving brief explanations only of the methods used in analysis. It gives first prominence to the answers required by management on the present working conditions of the crane, together with positive recommendations for improvements in these conditions.

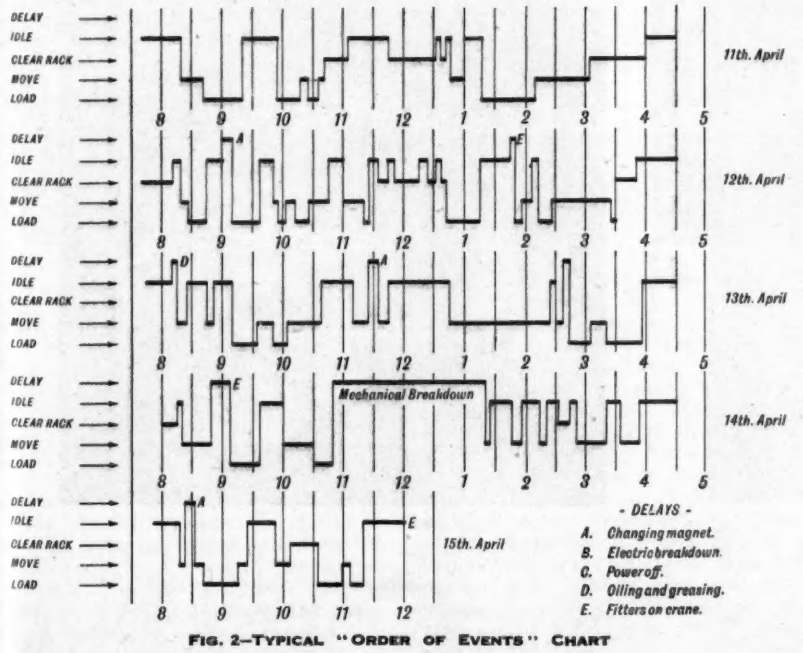


FIG. 2—TYPICAL "ORDER OF EVENTS" CHART

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 24, Victoria Street, London, S.W.1.

POWER-DRIVEN DERRICK CRANES

No. 327, Part 1 : 1951.—The fourth revision of this standard, which was originally published in 1928, follows similar lines to the previous editions, in that it indicates the minimum requirements for power-driven derrick cranes of the normal type and is intended to secure the general observance of such fundamental principles as appear desirable to secure reliability and safety without hampering the freedom of the crane maker in his selection of the most appropriate design for the purpose in view.

It deals with Scotch derrick, guy derrick and power derrick cranes and lays down requirements relating to the crane as a whole, including electrical equipment and provisions for testing.

The clauses in regard to electrical wiring and cables have been brought into accord with the twelfth edition of the regulations for the electrical equipment of buildings recently published by the Institution of Electrical Engineers. Another feature of the revision is the modification of the appendix relating to the design of struts. A new appendix follows the general method of application of the Perry-Robertson formula for struts adopted in other British Standards and this indicates a step in the evolution of the crane standards in that enquiries are being made into the question of permissible stresses in crane structures. It is considered to be probable that before long it will be possible to issue a supplement in order to amend the standard to deal with stresses in the crane structure on similar lines to those followed in other British standards, such as B.S. 449, "The Use of Structural Steel in Building," whereby the principle of using a factor of safety will be replaced by the specification of maximum permissible stresses and appropriate factors for their modification to suit the operating conditions. Price 6s., post free.

FRENCH RAILWAYS' TRAIN FERRIES

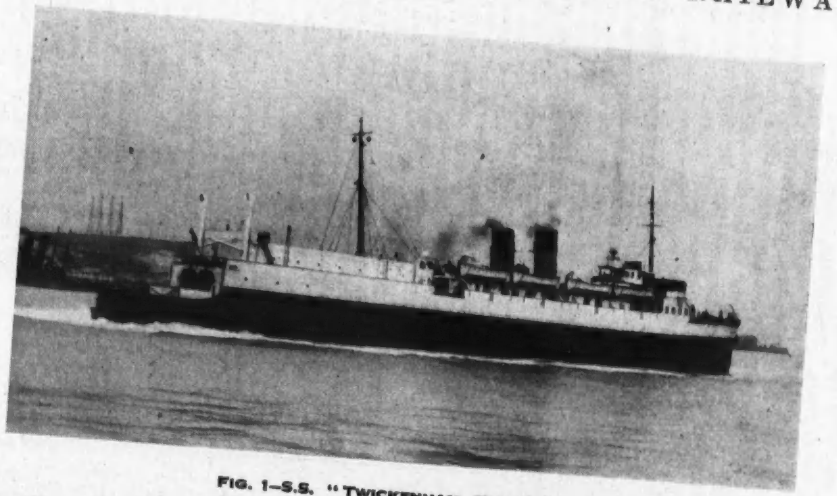


FIG. 1—S.S. "TWICKENHAM FERRY"

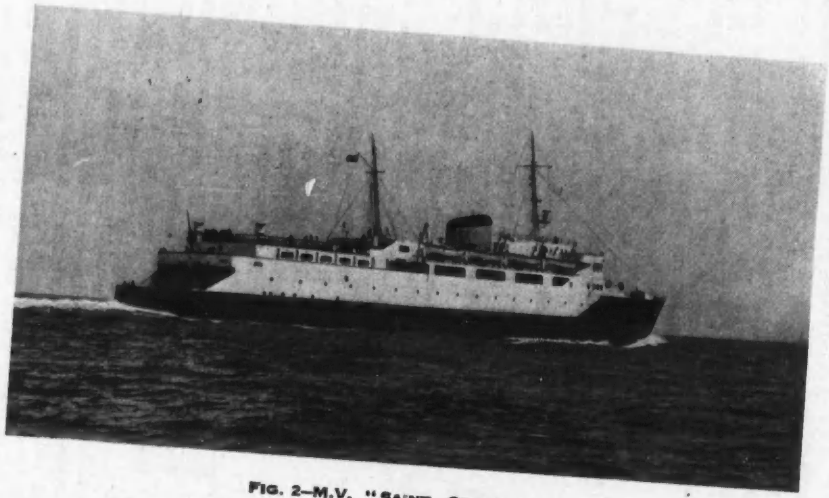


FIG. 2—M.V. "SAINT GERMAIN"

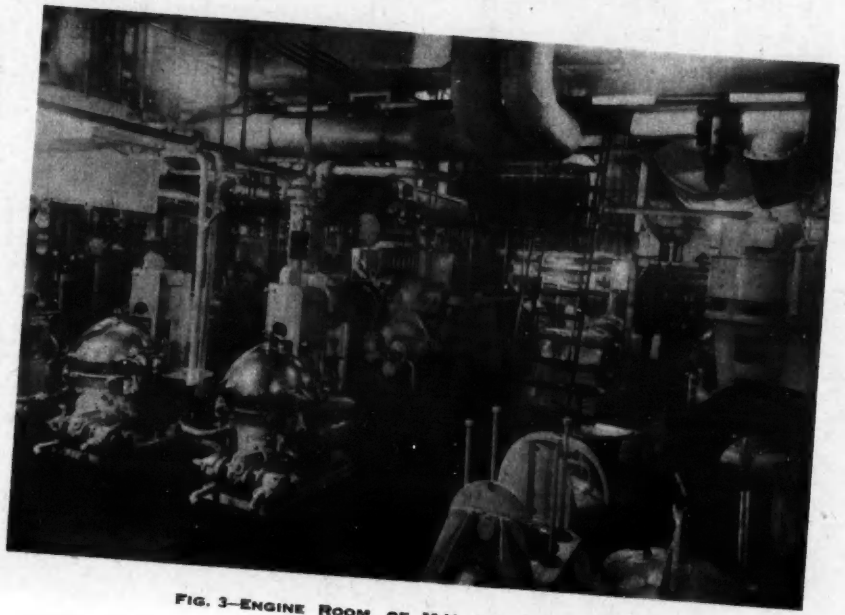


FIG. 3—ENGINE ROOM OF M.V. "SAINT GERMAIN"

FIG. 4—TRAIN DECK OF M.V. "SAINT GERMAIN"

French Railways' Train Ferry M.V. "Saint Germain"

By G. W. TRIPP, O.B.E., F.C.G.I., M.I.C.E.

IT is somewhat surprising that after the train ferry between Richborough (Kent) and Dunkirk had proved so invaluable in the 1914–18 War the then South-Eastern and Chatham Railway did not take it over and develop the service instead of letting the ferries go to Harwich. But after the Armistice there was a feeling that the Channel tunnel might eventually become a *fait accompli*.

As years went on the idea of a train ferry suitable both for passenger trains and freight increasingly gained favour, with a result that the Southern Railway placed an order with Swan, Hunter and Wigham Richardson, Ltd., of Newcastle, for three ferry vessels, each driven by four single-reduction geared turbines, to be supplied by Parsons, of Newcastle. Steam was supplied by coal-fired Yarrow boilers. These ships were delivered in 1934, their leading dimensions being: length, 346·8ft; breadth, 60·7ft; depth, 18·2ft; tonnage, 2830 gross. Prior to this, in 1927, a French company, the Angleterre Lorraine Alsace Société Anonyme de Navigation, initiated a service between Tilbury and Dunkirk, which was maintained by second-hand cross-channel steamers acquired from British railways. With the advent of the train ferry this service was terminated, but the French naturally desired to have their share in the cross-channel traffic, and by mutual arrangement one of the new vessels, "Twickenham Ferry" (Fig. 1), was transferred to the French flag. The day service of these steamers was limited to freight, but passengers are carried on the night sailings and those who wish can remain in the sleeping cars from London to Paris, while, if they prefer to use it, there is suitable passenger accommodation on the steamers.

As a result of the continued development of traffic the French Ministry of Marine ordered an additional vessel for the French State Railways, to be named "Saint Germain" (Fig. 2). She has been built at Elsinore, in Denmark, the shipbuilder being Helsinger Skibsvaerft og Maskinbyggeri A/S, who has had considerable experience in this class of vessel, having built all the modern ferry ships for the Danish State Railways to maintain communications between the Danish islands and the mainland. It is of particular interest that while the three other vessels are turbine steamers, "Saint Germain" is propelled by diesel engines, so that some interesting comparisons should be possible between vessels plying between the same ports and engaged on similar duties.

The problem of construction was not an easy one, for in the design of hull conflicting factors had to be taken into account, the water line of the vessel had to be sufficiently fine for the required speed to be attained, initial stability had to be ensured to minimise the heeling of the ship when embarking vehicles on the outer tracks, while satisfactory performance in a seaway was essential. Special research was necessary, and two different models were built and tried out in an experimental tank, so as to determine the best form of stern and propeller shaft brackets. Comparative tests were also made to ascertain whether outward or inward turning propellers were best suited to this specialised type of craft, the result being that outward turning propellers were adopted. The length and breadth had to be governed by the dimensions of the dock at Dover, into which the vessel has to be steered to put the gangway into position for embarking coaches and wagons, while the maximum width and form of stern are governed by the terminals at Dover and Dunkirk. The design of the whole ship is on modern lines.

The principal dimensions are:—Length overall, 379ft 8in; between perpendiculars, 366ft 9in; breadth overall, 62ft 2in; depth to train deck, 20ft 3in; depth to promenade deck, 35ft 8in; draught loaded, 13ft 6in; deadweight, 1300 tons. Propulsion is by two diesel engines constructed at the Elsinore Shipyard under licence from Burmeister and Wain. They are two-stroke, single-acting engines, each having nine cylinders of 500mm bore and a stroke of 900mm. These engines drive twin screws. The maximum speed is 195 r.p.m. and normal speed is 180 r.p.m., the maximum speed of the vessel being 18 knots. Electric current is supplied at 220V d.c. by three 200kW Burmeister and Wain four-stroke diesel engine driven generators, and an emergency generator of 25kW and a battery of 220V accumulators, come into service automatically should there be a failure of current. The general lay-out of the engine-room is shown in Fig. 3. In order to facilitate coming into the terminal stern first a bow rudder is fitted; it is electrically operated with telemotor control, as is also the main rudder, but in its case there is dual motive power. The windlass and five capstans, and all the pumps and auxiliaries, are driven by electric motors. There is a boiler to provide steam for domestic and other purposes, and steam connections are arranged for heating the sleeping cars while aboard, and at the same time their electric storage batteries can be charged. Fireproof doors are fitted, and a fire detection and extinguishing system has been installed, all complying with the latest regulations.

The vessel has been constructed to the requirements of the Bureau Veritas, being classed 1 DIV 3/3 (Manche) A. and C.P., and in compliance with the buoyancy conditions of the International Convention on Safety of Life at Sea, it has been arranged that two adjacent watertight compartments can be flooded without the ship capsizing as a result. Eight lifeboats are carried.

Comfortable accommodation for the ship's officers is situated on the boat deck, where there are also two double cabins, four single-berth cabins, and a spacious third-class lounge. At the forward end of the promenade deck there is a first-class lounge (Fig. 6) extending the full width of the ship and affording an uninterrupted outlook through large windows. Astern of this are a number of two-berth cabins and toilet accommodation, while further astern is a restaurant (Fig. 5) capable of seating eighty-two persons. The remainder of this deck is occupied by offices and more lavatories, and finally a garage for twenty-five cars, which can be driven on board straight from the quay by means of the embarkation ramps. Below is the train deck (Fig. 4), which has four sets of rails, the two central ones being arranged to accommodate the sleeping cars, which have a platform beside them to permit passengers to leave the cars, should they so wish, and have access to the promenade and lower decks. The four rails become two at the stern, where the sleeping cars and

FIGS. 5 AND 6—DINING SALOON AND FIRST-CLASS LOUNGE OF "SAINT GERMAIN"

wagons are embarked. This deck has a wood flooring up to rail level, so that it can be used for motor-cars when required. On the lower deck the engine-room is situated amidships, and forward of this deck are quarters for the engineers and crew, while nearer the bows are first-class sleeping saloons with suitable lavatory accommodation. Immediately astern of the engine-room there are two third-class sleeping saloons (for ladies and gentlemen respectively), each having forty-four berths, and the necessary toilets. Astern is further accommodation for the ship's crew. The vessel can carry 500 passengers, 248 of whom can have sleeping berths, 36 in cabins and 212 in the saloons.

On the bridge deck there is a spacious wheel-house and this is equipped with modern aids to navigation, including radar, radio direction finder and echo depth sounder. There is also a public address system which serves the accommodation of both passengers and crew.

As a class train ferry vessels can hardly be described as graceful, but if any one could claim good looks it would certainly be "Saint Germain," as our illustrations will show, for with her sturdy build, her two masts and modern funnel, there is something about her that makes her definitely handsome, while all her internal fittings are of a high standard, and the various pipes so often seen exposed in cabins of cross-channel vessels are conspicuous by their absence in "Saint Germain." In her construction welding has been resorted to to a considerable extent, but at the builder's request the frames are riveted to the shell and a riveted strake is retained.

When trying this ship it was noticeable that she was very steady in a heavy sea, and also that the vibration so inseparable from most diesel vessels has been reduced to a minimum. "Saint Germain" should prove a valuable addition to the fleet of train ferries plying between Dover and Dunkirk. During the inspection of the vessel it was interesting to observe that though she is of foreign design and construction, a number of British fitments have been used.

Methods of Assessing the Stability of an A.C. Power System

By R. F. LINSELL, B.Sc., A.M.I.E.E., A.M.I.Mech.E., M.I.Mar.E.

AN a.c. power system can function only when all of the generators are running in synchronism. Any sudden change in the load or in the arrangement of the system may disturb the generators to such an extent that one or more of them may fall out of step. This disturbance may happen although the load is well below the capacity of the generators, and when it does electricity supply may be dislocated over a wide area.

Up to a certain limit the system is stable and will return to synchronism of its own accord, while beyond that limit trouble is experienced. This article discusses how stability is calculated or measured and shows that existing methods of doing this are very laborious. It then describes a suggested improvement which would enable the stability of an a.c. power system to be assessed more easily.

Power Transfer Between Power Stations

Stability problems occur chiefly where two or more power stations are supplying a common load. A simple case is shown in Fig. 1 (*a*) and (*b*), where two power stations each consisting of one generator supply a load close to one of them. The two stations are tied together by a transmission line, which has a reactance X and a resistance R.

The vector difference between the internal voltages of the two stations OP and OQ causes a current I to flow in the line. The phase angle of I with respect to PQ is determined by the value of R and X. From this vector diagram (Fig. 1 (*c*)) it is possible to calculate the power transferred from station 1 to station 2. This calculation involves a long formula, but it can be simplified into the expression $P=\frac{E_1E_2}{X}\sin\theta$ if R is assumed to be zero.

Thus we see that for fixed values of E_1 E_2 and X the power transmitted depends on the angular separation of the voltage vectors and is a maximum when $\theta=90$ deg. The relative position of the generator internal voltage vectors is the same as the relative position of the axes of their rotor poles. Thus the power transmitted from one station to the other depends on the angular relationship of the two generator rotors. Fig. 1 (*d*) shows the power-angle curve.

The power transmitted will be a steady value if the rotor angle remains the same, but it will fluctuate if anything causes the rotor angles to vary (or causes the generator speeds to change relative to each other). It

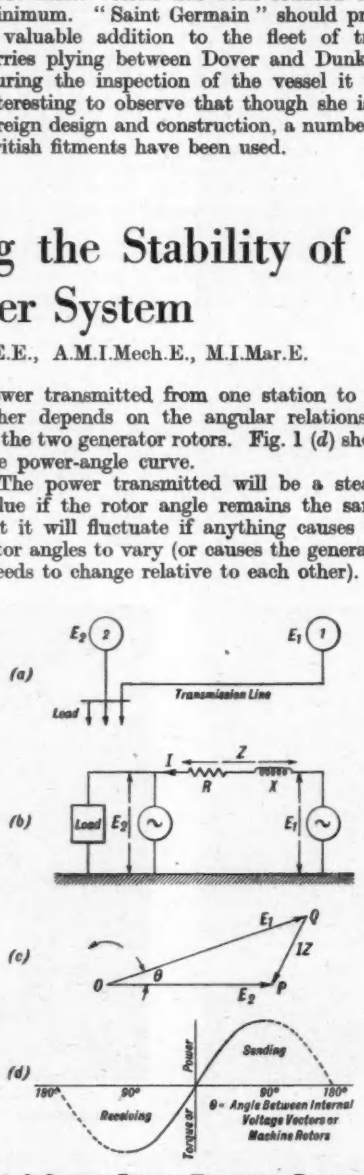


FIG. 1—SIMPLE POWER TRANSFER DIAGRAMS

should be noted that the torque exerted by a generator on its prime mover is also proportional to its rotor angle.

Power Stability

Consider Fig. 2 (*a*) and assume a power P_A is being transmitted from station 1 to station 2 when the angular separation between the voltage vectors is θ_A. If the load increases suddenly and the two generators do not respond equally, the angle θ may change temporarily. If it increases to θ_B (station 2 slows down more than station 1) more power P_B will be transmitted from 1 to 2. This extra load on station 1 will tend to slow it down, so that the angle tends to return to θ_A.

Similarly, if station 1 slowed down more than station 2 when the load increased, θ would decrease to θ_C and the power transmitted would be less. This change would relieve station 1 of some load and it would speed up to restore the angle to θ_A. Thus, after a small disturbance round about the point P_A, θ_A, the power may vary, but it always returns to the initial condition, which is therefore stable.

It should be noted that the system would still be stable if θ increased to θ_D momentarily, because P_D, although over the peak, is greater than P_A, so that station 1 would tend

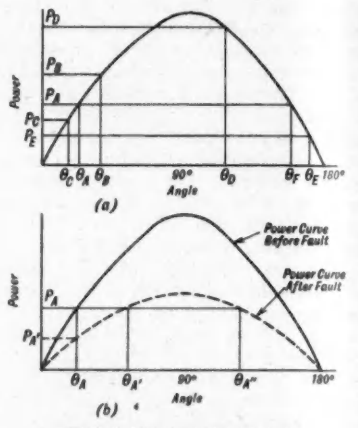


FIG. 2—POWER STABILITY

to slow down and reduce θ to θ_A again. However, if the angle increased as far as θ_E, since P_E is less than P_A, the load on station 1 would be reduced. This would cause station 1 to speed up and increase the angle still further, so that the two stations would lose synchronism. θ_F is the stability limit for the initial condition $P_A\theta_A$.

Even before synchronism was lost a very heavy current would flow between the two stations if the voltage vectors swung beyond 90 deg. This transfer might very well trip the circuit breakers between the two stations, leaving 2 to supply the load alone. Station 2 might then be overloaded and have to shed load rapidly in order to keep running at all.

In the description above it is assumed that a sudden change in load initiates the phase swinging between the generators. In practice, the load does not usually change so rapidly. A more likely cause of phase swinging is the occurrence of a fault on the transmission system, such as the tripping of one of two parallel lines, causing the reactance to be doubled. This may suddenly change the power-angle diagram to a different sine curve (shown dotted in Fig. 2 (*b*)).

The machine angles cannot change instantaneously with the result that the power, transmitted suddenly falls to $P_{A'}$. The machine governors also cannot change instantaneously, so that the prime mover at station 1 is putting power P_A into the generator while only $P_{A'}$ is going out. The excess power accelerates the generator and θ increases. When θ reaches $\theta_{A'}$ the generator will cease to accelerate relative to the other machine, but it will swing beyond $\theta_{A'}$ and may fall out of step with station 2 if it swings beyond $\theta_{A''}$. The two generator rotors will execute a damped oscillatory motion relative the each other, and the amount of phase swinging will depend upon the machine inertias and the electrical and mechanical

damping, as well as the electrical properties of the generators and transmission system.

Before the recent war, power stability problems did not receive very much attention in this country. Transmission distances were usually short and the phase angle between two power stations was seldom more than a few degrees.

There were at least two outages in England caused by stability faults in the 1930s. The best known was in 1936, when the whole of the South-East of England was without power because of a fault which started at Battersea power station. The other was in 1938, when a fault near Hams Hall power station caused extensive trouble in the Midlands.

Since the war the electrical load has often exceeded the capacity of the power stations. This has had three effects: first, it has often been necessary to transmit power over considerable distances from lightly loaded areas to dense load centres; secondly, the generators in use are operated closer to their mechanical and electrical limits; and thirdly, the voltage has frequently been dropped in an attempt to shed load. All of these three factors have tended to increase the chances of trouble due to instability, and there have, in fact, been more stability outages. An instance was in May, 1948, when a fault in Eastern England caused extensive dislocation of supply.

As a result of these developments more stability investigations are being made, and there is a growing tendency to equip generators with stability indicators.

Methods of Assessing Stability

Calculation.—It is theoretically quite possible to calculate whether or not a power system will be stable, but in practice the problem is usually so complex that several months of calculation would be required. A typical problem would involve several power stations, each consisting of several generators, feeding power over a network of lines and cables to several load centres.

Given the initial conditions, it is possible to calculate how the load is shared by the generators and what are their relative rotor angles. The problem then asks: what is the effect of, say, switching out one of the transmission lines? A fresh calculation solves the new distribution of load, and it is then necessary to calculate the angular motion of each generator rotor, knowing the accelerating or decelerating forces, the inertias and the damping. However, as each generator affects the others, it is necessary to solve a series of equations for each of a large number of short intervals of time. This is called a step-by-step method.

The complete mathematical statement of the stability problem involves elliptic integrals, and, when more than four machines are involved, can be solved only by tabular iterative methods, there being no formal solution. It is usual to reduce the system to an equivalent two or three-machine system, which can be solved fairly readily, but this often requires large assumptions which vitiate the solution.

Network Analyser.—The Americans experienced stability trouble in the 1920s, when engineering large transmission schemes, and they pioneered in the development of what are called network analysers to help solve power flow and stability problems.

The network analyser is in effect a stationary miniature-scale electrical model of the system under examination, and measurements in the model replace the tedious calculations. Machines, transformers, transmission lines and cables are represented in the analyser by equivalent circuits composed of resistances, reactances and capacitances connected in the correct proportions. These form the network which is fed at the appropriate places by voltages whose magnitude and phase angle is set to represent the internal voltages of the generators. Currents and voltages at different points in the network are then measured and translated into appropriate quantities in the system under examination. This operation greatly reduces the labour involved in power system studies. The initial stage, that of reducing the actual system to a series of equivalent circuits, is common to both methods of attack, but the solution of power flow equations in the analyser takes hours instead of days.

If the network analyser is to be used to solve a stability problem, the step-by-step method must be used as before, but the whole problem can usually be resolved in a few hours instead of several weeks.

In a recent paper* read before the Institution of Electrical Engineers it has been stated that a problem involving six machines used to require about one day's work for two men using a network analyser to obtain one set of swing curves. Of this time approximately 75 per cent was taken in computing the readings made at each "step" into information required for the succeeding step of the curve. This calculation, however, can be done by an electrical device developed by Dr. J. R. Mortlock, which makes it possible to obtain four sets of swing curves per day in a six-machine problem.

In England the first network analyser of the type described above was built by the Associated Electrical Industries, Ltd., and was opened in 1947 (The Engineer, Vol. 184, page 442). One other has since been built by another manufacturing company, and a third is projected by the British Electrical and Allied Industries Research Association (The Engineer, February 17, 1950, page 207). Before this, various colleges had built smaller network analysers of reduced accuracy, and one analyser working on an entirely different principle had been built by Messrs. Merz and McLellan at Newcastle in 1937 (*Electrical Times*, Vol. 117, page 307). This particular analyser was developed by Mr. C. L. Blackburn and uses transformers having tapped winding to represent impedances and admittances. Although less easily understood, this concept is very flexible, and the Blackburn calculator can be used for all types of network problems. For transient stability studies the step-by-step method of solution is used as with the conventional analysers.

In America there are now twenty network analysers owned by electrical manufacturers, power companies and colleges, while in other countries there is one in Brazil, one in Canada, two in Russia and one being built in India.

Direct Solution of Stability Problems

Although the network analyser is a great improvement on tedious calculation, it is natural that attempts should be made to obtain a direct solution to stability problems. It would clearly be more convincing to be able to see something swinging and watch it either settle down or swing out of step.

There have been two different approaches to the problem of direct observation of machine stability.

One method was to set up a miniature power system, using small rotating machines and to measure their rotor angles stroboscopically or with an oscillograph. This method was used in three different studies in America, using machines ranging from 4kVA to 625kVA, but was discarded because various scale effects introduced errors. Thus the machines could not be reduced to laboratory dimensions and became expensive.

It was the relative failure of this more obvious system, which led to the development of the first network analyser in 1929.

A French engineer, R. Robert, has recently revived the miniature machine technique and by adding many refinements has reported an accuracy of 0·5 per cent, using machines of 5kVA frame size (C.I.G.R.E. Report No. 338 (1950), Micromachines and Microreseaux). This approaches the desired laboratory scale but the equipment required is considerably more expensive and more cumbersome than that contained in a network analyser.

Griscom Model.—The other method proved to be a very elegant demonstration piece, but could be used only for the simpler problems involving two or three machines. The vector diagram in Fig. 1 (*c*) was brought to life by constructing the two voltage vectors OP and OQ as rods, hinged at O. The vector PQ was made of a spring which could stretch when a torque was applied tending to separate the rods. The stiffness of the spring was proportioned to the reactance of the transmission line, and the lengths of the rods to the magnitude of the voltages, so that the angle made by the rods was equal to the rotor angle in the actual machines.

This model, the principle of which is shown

Fig. 3—The Griscom Model

in Fig. 3, was devised by an American engineer, S. B. Griscom, who developed it enough to give quite good results when applied to relatively simple problems. The chief difficulty was that the spring did not have a truly linear characteristic and that it had a finite unstretched length.

Suggested Method of Solution Using Network Analyser

The Generator Unit.—The generator internal voltage vector in the A.E.I. network analyser is produced by means of two Selsyn units in series, as shown in Fig. 4. The first

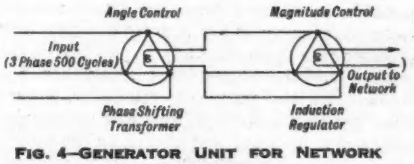


Fig. 4—Generator Unit for Network Analyser

acts as a phase shifting transformer and controls the angle, while the second acts as an induction regulator and controls the magnitude. The rotors of these Selsyns are positioned by gearing from control knobs on the front of the analyser panel.

A fairly obvious suggestion is to try to make the rotors of the generator unit angle-

* "Some experience with a British A.C. Network Analyser" G. Lyon, B.Sc. (Eng.), A.M.I.E.E., *Journal*, I.E.E. 1950, part II, page 697,

control Selsyns trace out the angular motions of the real generators they represent. It would then be possible to obtain swing curves directly from recordings of the rotor movement, and the time required to solve a transient stability problem would be greatly reduced. This could be done by removing the positioning gearing and allowing the rotor to turn freely under the combined influence of an externally applied positioning torque and its own restraining torque, inertia and damping.

It should be explained that the removal of the gearing from the Selsyn rotor does not cause it to be driven round as an induction motor, because the rotor is being fed with a single-phase supply from the rest of the network. This causes the rotor to lock itself in an equilibrium position from which it resists displacement.

In order to make the Selsyn rotor trace out its own swing curve the following requirements must be fulfilled:—

(1) The rotor must be freely suspended and have negligible inherent friction.

(2) The rotor must be positioned by an externally applied torque which is proportional to the driving torque of the prime mover.

(3) The rotor must resist displacement by a torque which is proportional to the generator synchronising torque, and which varies as the sine of the angle of displacement from its no-load position.

(4) The mechanical inertia of the rotor must be proportional to that of the generator and prime mover rotors.

(5) Any damping in the generator or prime mover must be reproduced in the Selsyn to the same scale as the mechanical inertia.

Then, if the torque, inertia and damping are reproduced to the same scale, the Selsyn rotor will oscillate with the same period as the rotor of the real machine. The logic of this statement cannot be denied, but the demonstration of the idea in practice clearly depends on the development of a Selsyn having all the features enumerated. Such a device might be called a dynamic stability model.

Work Already Done.—The original idea of a dynamic stability model was due to Mr. W. S. Stuart, of Leeds University, and it was partially developed by him and the author of this article in 1938.

Previous work had shown that an iron-cored rotor tended to develop a torque in the direction of rotation of the field, even when open-circuited. This was thought to be due to eddy currents passing between the laminations. It was decided therefore to wind the rotor coil on a wooden former. This effectively reduced the unwanted torque, but it also reduced the restraining torque developed.

The generator unit was therefore rebuilt so that the rotor could be hung from a torsion wire and torque applied to it by rotating the torsion head. With this apparatus it was possible to demonstrate that the rotor did resist displacement by a torque which was proportional approximately to the sine of the angle, but the model was altogether too delicate for the purpose. Moreover, it was observed that a torsion wire was not a suitable agent for applying torque, as the movement of the rotor modified the torque applied.

The next stage was to revert to the iron-cored rotor mounted in ball bearings, and apply the torque by means of a pulley wheel, counterbalancing the induction torque at the equilibrium position. This produced a more powerful device, and it was possible to obtain a torque-angle curve which was very close to a true sine curve.

Using the unit with an iron-cored rotor, it was demonstrated that the torque developed was greatly reduced if additional reactance was added to its rotor circuit. This result is in line with the formula stated earlier, which says that power (and hence torque) is inversely proportional to the reactance between the voltage vectors.

Another test was made to measure the watts and reactive volt-amperes in the rotor circuit as the rotor was turned between its two limits of stability. This was done by measuring the rotor voltage and current with a Drysdale a.c. potentiometer and converting them to active and reactive components of power. Fig. 5 shows that the points obtained

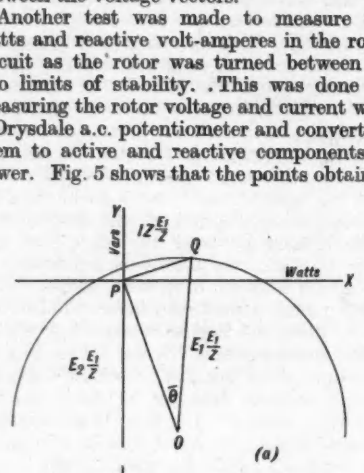


FIG. 5—CIRCLE DIAGRAMS SHOWING ACCURACY OF STABILITY MODEL

lie very close to the circle predicted from the vector diagram.

A further test was made to measure the increment of torque which could be applied to the rotor for various values of initial torque. The points obtained compared very well with a line predicted from the mathematics of the sine curve, as shown in Fig. 6. Thus it was demonstrated that the dynamic stability model had many of the characteristics of a synchronous machine and it appeared to be

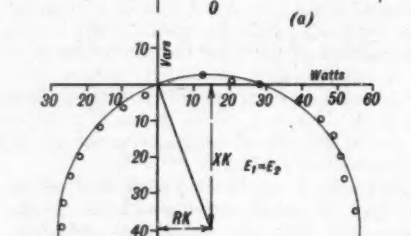


FIG. 6—EFFECT OF SUDDEN INCREMENTS OF TORQUE

suitable for use in stability studies. However, the work was never pushed to a firm conclusion, largely because there was no network analyser in this country suitable to use it, and therefore no active demand for its development.

Recent interest in network analysers and stability has caused the idea of the dynamic stability model to be revived, and one will shortly be made and tested in the A.E.I. analyser.

Details of Work to be Done.—It is clear that considerable development work must be done before the dynamic stability model can be used with confidence. The most obvious of the details to be worked out are:—

(1) It is necessary to determine how to proportion the inertia of the model to that of the machine. The adjustment of the inertia can be made easily by adding flywheels to the shaft of the model.

(2) An adjustable damping device will have to be evolved which will give damping proportional to that experienced in synchronous machines.

(3) A torque applying device will have to be evolved which is easily adjustable so as to be proportional to the prime mover driving torque, but which does not vary when the rotor turns unless required to do so to simulate governor characteristics.

(4) Some means of measuring and recording the rotor angle must be devised. This should preferably be made to record on a multi-element oscillograph.

(5) The reactance of the model must be proportional to that of the real machine and, observing that the machine reactance changes during fault conditions, the model reactance must also vary in a similar manner. It is possible that the model will, in fact, behave like the real machine; if not, the reactance will have to be added externally and controlled independently.

(6) It might be desirable to make the inertia scale different from the torque scale, so that the period of oscillation of the model would be longer than that of the real machine. That might be necessary to allow switching to be performed in the network to simulate the action of, say, auto re-closing circuit breakers.

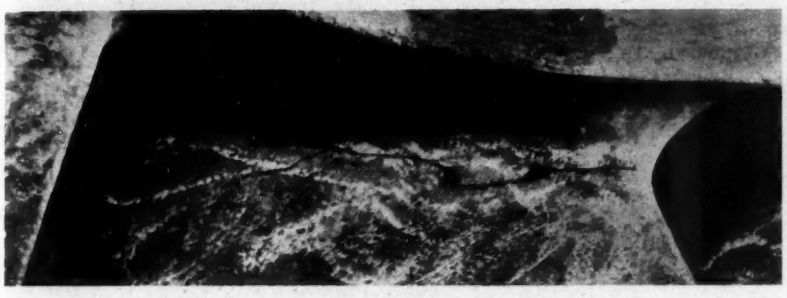
CONCLUSION

The development of a dynamic stability model will enable operating and designing engineers to obtain a rapid check on the stability of a.c. power systems, and will enable the effect of the various factors which influence stability to be demonstrated visually on a laboratory scale.

Turbine Vibrations at Parker Dam

AFTER considerable effort, a vibration problem involving the turbines at the Parker dam of the Bureau of Reclamation, on the California-Arizona border, has now been solved. In 1946, three years after the four 40,000 h.p. turbines had been installed in the power station of Parker dam, it was found that the rotors were vibrating so badly that the turbine runner blades were beginning to crack. Under the constant vibrating action, the cracks gradually grew, spreading out on the blades of each of the four turbines. The most serious damage had taken place on unit No. 1, which had been installed in December, 1942. During the first major overhaul in the spring of 1946, when the extent of the damage was investigated, it was found that fourteen of the fifteen runner blades were seriously cracked near the crown of the turbine runner. The extent of the cracking on one of the blades of this unit is shown in the accompanying illustration. In addition, the high-velocity flow of water at sub-atmospheric pressures had pitted out critical areas of metal. The first repairs made on this and on the other three units at that time consisted of chipping out the cracked and pitted areas and of partially filling the cavities with a soft steel welding material. The remainder of the pitted areas was then filled with stainless steel rod and ground to the proper contour. However, these

alterations did not eliminate the cause of the cracks, and within a short time they reappeared. Then, in an endeavour to eliminate the vibration, the leading edges of the runner blades were sharpened by welding a ½in square bar on the edge for the full length of the blade. However, no significant reduction in the vibration was apparent. Next, round metal rods were inserted between adjacent blades on all four runners to reduce the vibration, and cracks grew where none had been before. Metal rods similarly placed on the trailing edge of the runner blades were equally ineffective. It was then decided to insert 1in pipes, perforated with ½in diameter holes, into various parts of the runners, and to pump compressed air into appropriate areas, hoping that the air would act as a cushion for the vibration. Although this resulted in a reduction in the magnitude of vibrations, the runners continued to crack at a serious rate. Later efforts included the trimming of the edges of the wicket gates and, finally, as an emergency measure, the complete rewelding of the broken runners on the theory that the repair material would be considerably stronger than the original metal. Again, these efforts were of no avail, as the runners cracked in the same location about as rapidly as before. To minimise the cracking the power station operators, in August, 1948, were forced to restrict the flow of water to eight-tenths of the full gate opening, a condition which existed until January of this year.



CRACKED BLADE OF TURBINE RUNNER AT PARKER DAM

In the spring of 1950 a comprehensive test was conducted on unit No. 1 with the aid of pressure cells, strain gauges and acceleration meters. Every conceivable segment of the runner and of the related water passages was covered and all the instruments were connected to a slip-ring collector placed on the turbine shaft in the pit above the runner. The turbine was then started up as soon as the water again flowed in the unit, and readings were taken from all the instruments in operation. The data thus obtained showed conclusively that the only possible source of the trouble existed at the trailing edge of the runner blades. From this evidence it was recommended that the trailing edges be sharpened, reducing the weight of each blade by 20 lb. This modification of the trailing edge would enable the water to follow a smoother path in its descent through the runner, helping to minimise the vibration. Observation of the unit after modification disclosed that the vibration set up by the vortex trails at the trailing edge of the runner blades had been completely eliminated. From the inspection it was concluded that there was no need for concern over possible increased erosion or pitting caused by the larger opening between blades; paint marks on the blades made during the tests in July were found to be undisturbed. Subsequent operation has shown that the output of the turbines, after streamlining of the runner blades, has been increased by almost 5 per cent.

TWELVE-CHANNEL CARRIER TELEPHONE SYSTEM FOR USE ON CABLES.—The Automatic Telephone and Electric Company, Ltd., Liverpool, 7, has issued, in the form of a reprint from *The Strowger Journal*, July, 1950, an article by T. B. D. Terroni, describing a twelve-channel carrier telephone system for use on cables.

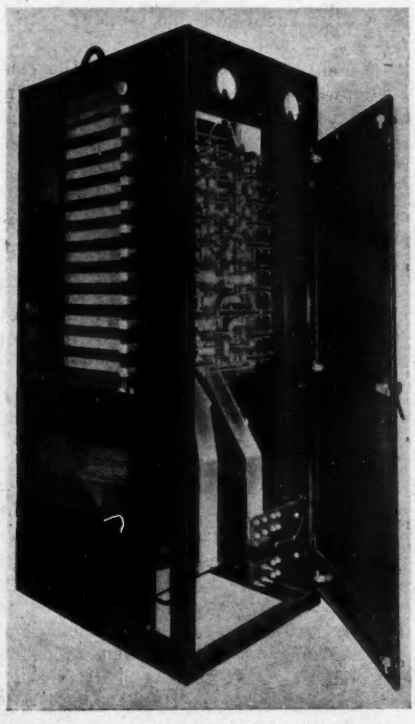
A Forced-Cooled 2000kW Resistor

A NEW form of forced-cooled resistor has recently been manufactured by the British Thomson-Houston Company, Ltd., Rugby, for continuously absorbing approximately 2000kW of electric power. The first application of this compact resistor unit (designated type "ZP") is for testing the generators of diesel-electric locomotives. It can be used, also, for rheostatic braking on large electric and diesel-electric locomotives, where space is limited, but considerable amounts of power have to be dissipated.

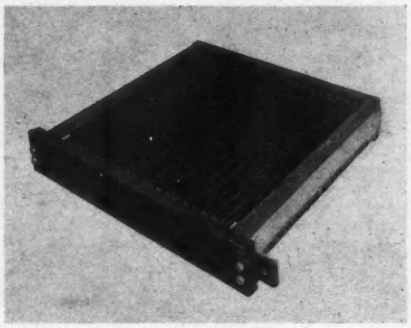
In the unit illustrated, a motor-driven fan at the bottom of a welded angle-iron enclosure forces air through a bank of resistors mounted vertically within the enclosure. Aluminium-chromium-stainless-steel strip having a high specific resistance and low-temperature coefficient is used for the resistor elements, the strip being formed into a "flat" V-shape to give rigidity and ensure maximum cooling from the air flow. By using continuous strip supported in a treated asbestos-compound frame, as illustrated herewith, expansion and contraction of the strip is provided for and, by mounting a number of frames together, the air passes over each resistor in turn. The assembly of frames may be vertical or horizontal, depending upon the space available for the complete unit.

By connecting the fan motor, which is rated at 37 h.p., in parallel with part of the resistor elements, the amount of cooling air provided is approximately proportional to the load, while a diffuser between the fan and the resistor elements ensures an even distribution of air.

Selector switches are provided so that the resistors may be readily connected in series or parallel groups to suit any particular load requirement. The selector switches have blades with silver button contacts which engage with silver-plated switch-clips to give a high-pressure dome contact. The switches are mounted on insulated bars in front of the resistor frames and are accessible through the front door of the enclosure, as shown in one of our illustrations. Connections between the switches and the resistor terminals are made with silver-plated copper straps. All terminals and tappings on the resistor elements are securely welded on.



2,000KW FORCED COOLED "ZP" RESISTOR



RESISTOR UNIT

Although designed primarily for traction purposes, this resistor unit will doubtless be found useful for other applications where a loading device of high capacity and constant resistance value is required. The unit illustrated is 8ft 6in high, 3ft wide and 4ft 2in deep, and its weight complete is 1 ton 9 cwt. The compact size of the unit makes it ideal for use on engine test beds, with generators already mounted in position on site, or in any similar cases where space is at a premium and a large amount of power has to be dissipated.

Technical Reports

Rates of Rise of Restriking Voltage at Circuit Breaker Positions on 66kV Systems. (Systems D, E, F, G, H and K.) (*Ref. G/T252*). By L. Gosland, B.Sc., M.I.E.E., and J. S. Vosper, B.Sc. (Eng.). The British Electrical and Allied Industries Research Association. Price 10s. 3d., post free.—This report gives details of the restriking voltage characteristics of the six remaining systems in the restriking voltage survey on 66kV systems in Great Britain, which has been conducted by the E.R.A.; other 66kV networks (A, B and C) were dealt with in previous reports, ref. G/T227, G/T235 and G/T236. Each system is treated separately to conform with the earlier reports in the series, and the material presented includes descriptions and circuit diagrams of the respective systems. The results are tabulated and plotted to show the relationships between R.R.R.V. and short circuit MVA. Conclusions have been deferred, since it will be of much greater value to combine the results for all the systems to obtain a picture of the restriking voltage characteristics for 66kV systems generally. This will be done in the revised summarising report for the series, (Ref. G/T239.)

Intrinsically Safe Electrical Apparatus: Relation of Igniting Current to Circuit Inductance for Inflammable Mixtures of Blue Water-Gas with Air. (*Ref. G/T258*). By E. M. Guenault, M.Sc., Ph.D., and E. Atherton. The British Electrical and Allied Industries Research Association, price 6s. 3d., post free.—This report covers the determination of the range of mixtures of blue water-gas with air most readily ignited by the sparks produced by the rapid interruption of an inductive circuit operated at 24V direct current and with the relation, for such mixtures, of igniting current to the circuit inductance. Under the conditions of these tests it is found that such mixtures of water-gas with air are generally more readily ignited than the most readily ignited mixture of coal gas with air, but are less readily ignited than the most readily ignited mixture of hydrogen with air.

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INTERNATIONAL HEAT TRANSFER CONFERENCE

THIS week there has been held in London a rather remarkable conference. It was organised by the Institution of Mechanical Engineers, jointly with the American Society of Mechanical Engineers, and about 100 papers were presented and discussed in a three-day meeting, which concluded with a dinner last night. The subject was "Heat Transfer" and the papers presented were divided up among "sections" concerned with, respectively, heat transfer with change of state; heat transfer between fluids and surfaces; conduction in solids and fluids; radiation, instrumentation, measurement techniques and analogies; and special problems. At a final session further discussion took place upon points of special interest that had been brought out at the earlier sessions.

Heat transfer is a subject of very wide application in engineering. There leaps at once to the mind of an engineer to whom the words heat transfer are mentioned, the need for knowledge of that subject in the design and operation of, for instance, boilers, condensers, coolers, radiators, air heaters and similar equipment intended specifically for the transfer of heat. But, of course, problems in heat transfer occur in many mechanisms not designed especially for that purpose. In all heat engines such problems arise. The design, for example, of internal combustion engine pistons is heavily influenced by them; they can by no means be neglected in steam turbine work; and if the gas turbine is to operate at those higher temperatures that will raise its thermal efficiency to levels comparable with those attainable with steam, methods of blade cooling will need to be adopted. Nor is that all. The need to have a knowledge of the principles of heat transfer turns up in the design of innumerable other devices, of which only a very few can be mentioned here, such as vehicle brake drums, bearings, gun-barrels and high-speed rockets. The problems to be studied are of many differing kinds. The worker in this field is not concerned only with the thermal conductance of metals and of insulating materials, the transfer of heat across a boundary from gas or liquid to a metal or other solid surface or vice-versa, or between sliding and possibly lubricated surfaces. The changes of physical state of materials introduce complicating factors. What is the mechanism of the evaporation of drops? How do drops form during condensation? What is the effect of a film of liquid upon the rate of heat transfer between a tube and a surrounding gas? Then there is the great field of heat transfer by radiation; and the distribution of temperature throughout a body through which heat is flowing may have important influences upon its design. The flow of liquids and gases brought about by differences of temperature influences both the rate at which heat can be added or subtracted from them and the design of the device in which heat transfer takes place. Nor are all the problems connected with the combustion of fuels to be forgotten. Many of the papers presented at the conference are so highly technical and mathematical that only those who have made a study of the special subject are competent to discuss them. Others, however, have immediate relevance to practice. The whole, papers and discussions together, when published here and in America, as is intended, will form a remarkable survey of existing knowledge upon a subject of fundamental importance in engineering.

It might be supposed that it was the importance of the subject that suggested to the two organising institutions that a joint conference would be welcomed by engineers. For, partly owing to the stimulus of wartime conditions, much was learned during the war about heat transfer, while, at the same time, security considerations made it difficult adequately to circulate that knowledge. The holding of the conference has certainly been timely. But, in fact, men's minds seldom work that way. Since the war there has been increasing co-operation between the Institution of Mechanical Engineers here and the American Society of Mechanical Engineers. The idea for the conference just concluded found birth, therefore, in the desire to make that co-operation closer, a desire that Sir Henry Guy, then Secretary of the "Mechanicals," and Col. Davies, Secretary of the A.S.M.E., found to be mutual when the latter visited this country at the time of the "Mechanicals" centenary in 1947. The selection of the subject came later. But it is difficult to believe a better choice could have been made. Furthermore, from the time the seed was sown the conception of what the conference might be, expanded. For, through its liaisons in the Conference of Engineering Societies of Western Europe and the United States and the Conference of the Commonwealth Institutions, the Institution of Mechanical Engineers was able to draw in contributions from other nations. In effect, for three days in London, there has been held a world conference of engineers upon a subject of fundamental importance to them.

THE S.B.A.C. DISPLAY

IT can be justly claimed that the annual flying display and static exhibition held at Farnborough has become an event of which the entire aeronautical world takes special notice. For, even were it not the only display of its kind attempted by any nation, no other could assemble on one airfield an array of aircraft, of engines and equipment, so diverse in character and yet so advanced in design. This year more than ever the effect of the relatively sudden impact of the development of the gas turbine upon aircraft design and operation has proved obvious. That device is shown this year fitted to two-thirds of the aircraft displayed, and those aircraft, moreover, are production rather than prototype machines. It is also apparent at the display that, in consequence of several recent critical decisions the bulk of Britain's future offensive and defensive aircraft strength is henceforth to be committed to airframes of quite radical modern design and to a form of propulsion yet in its infancy.

Since the war there has been repeated, but by no means unreasonable, delay in reaching decisions upon the kinds of aircraft that should form the air armament of this country. But under present circumstances the need to produce a sufficient number of fighter and bomber aircraft has become so pressing that some decisions have had to be made irrespective of the possibility of obsolescence intervening early. Special attention has been paid, therefore, by those present at the display to the demonstration of the Hawker and Vickers interceptor fighters, which are now to be produced in quantity. Performance figures are naturally secret, and it is still a matter of some conjecture whether these machines can be flown at supersonic speeds under any conditions in either level flight or otherwise. In this connection it is of interest to recall that the order made by the Ministry of Supply, forbidding pilots to attempt supersonic speeds, applied specifically to the Miles supersonic project which was then dropped. The lamentable fact that over thirty British test pilots and their machines have been lost from different causes in this country alone since the war suggests the grounds upon which this order was made in respect of that particular hazard. Presumably, any speed restrictions which may now

apply to these present interceptors are those set by the makers. It is perhaps significant that the Hawker "P1067" has been stated by the Air Minister to be faster than any known fighting aircraft. This statement includes the American "Sabre" interceptor, which is known to have flown under unspecified conditions at supersonic speeds and which has been flown by British pilots both in this country and in the U.S.A. It has also been disclosed that one version of the Hawker machine is fitted with a liquid propellant rocket motor, giving 2000 lb thrust at sea level in addition to its normal jet turbine thrust. It is estimated that at very great altitudes the power of this aircraft is doubled with this rocket motor in use. In the realm of bombing aircraft the first four-engined jet bombers are to be seen at the display. The Vickers "Valiant" machine, stated to have been ordered in the design stage, shows certain radical departures from any contemporary design, as was expected, and its performance has been officially quoted as superior in all respects to the "Canberra" bomber. No references of any kind have so far been made to the Short "SA/4" four-jet machine. In both fighter and bomber categories, therefore, this country now appears to have machines of superior design to any other. They are worthy products with which at least to commence the re-establishment of this country's air strength. An issue of equal urgency that has had to be decided relates to the type of gas turbine to be adopted for the propulsion of these new production aircraft. The advantages and disadvantages of both the axial and centrifugal compressor have long been debated by firms making either or both types. The particular advantage of the centrifugal compressor is the simplicity in manufacture of its impeller, as against the prodigious production problems which can be envisaged in the manufacture of vast quantities of axial compressor blading and in the development of suitable machine tools. But the axial compressor enables a higher compression ratio to be adopted and compression takes place at higher efficiency. It can be contained within a smaller diameter and its future development seems likely to profit to a greater extent from knowledge gained in the wider field of aerodynamic research—at least in so far as subsonic inlet velocities are concerned. Though there is no reason to suppose that with more vigorous research on impeller and diffuser design the efficiency of centrifugal compression could not be improved, the decision has been taken—we think, rightly—to power the two heavy bombers, and the two interceptor fighters already mentioned, the new Supermarine "508" twin-engined naval fighter, the "Canberra" and others, with axial-flow gas turbines. That engine is for all these craft the Rolls-Royce "Avon" jet turbine, the Mark 1 version of which produces 6500 lb sea level static thrust. The decision to concentrate production upon one make of engine is a bold one. If it is, indeed, a fine tribute to the Rolls-Royce reputation, it also sets upon that company a grave responsibility. To achieve the enormous output of engines planned it is going into quantity production in the Derby and Glasgow factories of the parent company, as well as with the Bristol Aeroplane Company, D. Napier and Sons, Ltd., and the Standard Motor Company.

This country can claim a lead in the development, if not in the conception, of yet another form of aircraft, the tailless delta wing machine. No fewer than four aircraft with this wing plan form are flying in this country, and two are being demonstrated during the display. Theoretical analysis has suggested that the wing form most favourable to Mach numbers closely approaching 1 is one with a degree of sweepback and low values of thickness/chord ratio, wing loading and aspect ratio. It is advocated from structural considerations that these properties might be most simply and advantageously embodied in a triangular wing plan form. The latest flying reports indicate that the performance of at least one of the aircraft built to this plan has exceeded expectations over a wide speed range. Finally, turning away, not without relief, from consideration of military craft, it is very well worth noting that this country has been the first to apply gas turbines to airliners. The de Havilland "Comet" with pure jet engines and the Vickers "Viscount," amongst others, with propeller turbine engines, are aircraft so soundly conceived that both, after remarkably short development periods, are now ready for scheduled operations on several routes. The "Comet" machine virtually doubled the speed and height at which contemporary aircraft of comparable size and purpose were cruising. Although the "Comet" was designed several years ago to cruise in the region of 500 m.p.h. at 40,000ft, it may well prove that these conditions will remain the optimum for passenger travel for many years.

Obituary

SIR HOLBERRY MENSFORTH, K.C.B.

We record with regret the death of Sir Holberry Mensforth, which occurred at his home, "The Red House," Hazlemere, Bucks, on September 5th, in his eighty-first year. Sir Holberry was well known in industry as a distinguished engineer and a sound administrator. Until his retirement in 1945 he had been a director of John Brown and Co., Ltd., and its associated companies since 1931, and was for some time chairman of the English Electric Company, Ltd., and Edmundson's Electricity Corporation, Ltd.

Sir Holberry was born at Bradford, Yorkshire, in 1871, and in his youth it was his parents' wish that he should study law. That profession, however, did not appeal to him, and, following an elementary education, he was apprenticed to a small firm of general engineers in Bradford. Before his apprenticeship ended, it is recorded, he was put in charge of the shop. In his early days Sir Holberry was particularly interested in the development of the gas engine and in its application to blast-furnaces.

In 1904 Sir Holberry entered the Trafford Park works of the Metropolitan-Vickers Electrical Company, Ltd.—or British Westinghouse Company, as it then was—as a draughtsman. He made rapid progress with the firm, and six years after joining it he was appointed superintendent and chief engineer in the engine department. In 1917 he became general manager of the Trafford Park works, in which appointment he revealed not only his ability as an engineer, but also his ability to administer successfully a large industrial organisation. Sir Holberry, for example, was a pioneer of works committees, and was also a keen advocate of progressive methods of engineering education. Although he himself had not received university training, he was one of the first industrialists to appreciate its value and to attract graduates to his works as apprentices.

During the first world war, in addition to running the Trafford Park works, Sir Holberry was given the arduous task of chairman of the Manchester and District Armaments Output Committee. His work in that office was recognised by the award of the C.B.E. in 1918. After the war he was appointed Director-General of Factories, and was responsible for arranging the closing down of redundant arms factories, and so reorganising the remainder that they could

SIR HOLBERRY MENSFORTH

compete efficiently with private industry. Recognition of Sir Holberry's work for the Government in that office was accorded in 1923, when he was created K.C.B.

In 1925 Sir Holberry accepted the position of managing director of Bolckow, Vaughan and Co., Ltd., a firm of iron and steel makers and colliery owners on the North-East Coast. At that time the post-war depression had set in, but Sir Holberry, with his accustomed energy, introduced many new methods and did much, during a difficult period, to improve trade union and management relations, especially in the collieries. In 1931, Bolckow, Vaughan and Co., Ltd., was merged with Dorman, Long and Co. Ltd., and Sir Holberry continued his activities as a director of the latter company and was personally associated with the building of the Sydney Harbour bridge.

Shortly afterwards, however, Sir Holberry decided to enter new fields, and there began an even more active part of his career. He became chairman of the English Electric Company Ltd., in which he initiated several schemes for modernisation. He also took up the chairmanship of Edmundsons Electricity Corporation, Ltd., a holding company with about sixty subsidiaries controlling electricity supply undertakings in large areas of England and Wales. In addition, in 1931, Sir Holberry was invited to join the board of John Brown and Co., Ltd., as a non-executive director, and he remained on this board and on the boards of the main associated or subsidiary companies, Thos. Firth and John Brown Ltd., Westland Aircraft, Ltd., Markham and Co., Ltd., Cravens Railway Carriage and Wagon Company, Ltd., until under the pressure of advancing years he retired in 1945. He was on the board of the Tredegar Iron and Coal Company, Ltd., until his

death. During his service with John Brown and Co., Ltd., Sir Holberry made many friends, both amongst his colleagues and the staff, who all had the highest regard for his advice on matters of high company policy and on engineering. He spent much time at the Clydebank yard, particularly in the marine engine works, where his help was much sought during their reconstruction, and he was closely associated with the building of such ships as the "Queen Mary" and "Queen Elizabeth."

Sir Holberry was a member of the Institution of Civil Engineers and the Institution of Mechanical Engineers, taking until recently an active interest in their affairs. He was also a vice-president of the British Electrical and Allied Manufacturers' Association. His contribution to the engineering industry, during his distinguished career, has been no small one, and is one which, undoubtedly, will be long remembered.

Literature

Economic Aspects of Atomic Power: An Explanatory Study. Under the direction of S. H. SCHURR and J. MARSCHAK. The University Press. Princeton, U.S.A. Price 6.00 dollars.

THE study which has led to the production of this book was set on foot in the U.S.A. by a Committee on Social and Economic Aspects of Atomic Energy, appointed by the Social Science Research Council, and carried out by the Cowles Commission for Research in Economics, with the financial support of the Rockefeller Foundation and the Life Assurance Association of America. Although, as is realised in the Preface, the future may well hold numerous peaceful economic uses for nuclear processes, the present study has been restricted to those applications which seem least remote and depend on a steadily controlled release of energy within a continuing structure and not by any explosive reaction due to the fission of heavy elements or the fusion of light ones. It is admitted that the objectives obvious to-day may not prove the most important in the end; the generation of electric power from heat released by nuclear fission, or the conveyance from reactors of low-temperature energy for residential heating, may give place to the discovery of how to convert nuclear energy directly into electric energy; if and when this happens the entire situation would change.

These facts may make the reader wonder whether so detailed a study at the present time may not be somewhat premature. Can it be useful to go so far in the study of probable working costs in relation to existing practice when so little is known, or when, for good and adequate reasons, so little can be revealed? It must be admitted that in any comparison of costs at this time the risk of incorrect deductions has to be faced, but, on the other hand, it is useful to have for future reference an analysis of costs in existing processes of manufacture in a number of industries for, some day, a close assessment of the right place in such industries of nuclear energy, in its various aspects, will require to be made. In the meanwhile, even these necessarily tentative estimates may afford useful guidance. One of their unavoidable uncertainties is the factor that atomic power can be produced as a by-product in the manufacture of nuclear weapons, when it becomes in effect a subsidised service since all military costs are met by the normal financial provision made by the State for its fighting Services.

The book is divided into three sections: the first and shortest has as its aim an economic comparison of atomic and conventional power; the middle portion, which absorbs about half the book, is devoted to the problem of employing atomic power in selected industries, ranging from the manufacture of flat glass to that of fertilisers, with a closing discussion on the effects of atomic power on national and regional economics, and its application especially to the backward areas of the world. The Study Group that advised on the planning of the book must have had to make up its collective mind at an early stage on the likely attainment of their aims by workers in a wide variety of investigation. Of these one of the most important is whether reactors capable of "breeding" fissile materials are possible or not. If each pound of uranium consumed in a reactor were to produce just that amount of fissionable material, the plant could in theory continue to work indefinitely without any further supply of fissile material from outside. The aim will, of course, be to design the plant so that a rather larger amount than this is produced, to the end that the original store will be gradually increased, and other reactors be fed as well. If happily this can be achieved normal uranium (238) can be consumed, and the world's accessible stores of that element will go all the further. Success in this endeavour is anticipated (pages 8 and 9 of the book), and that thorium as well as uranium will be of use as a source material. None the less, it is admitted that, in the words of the United States Atomic Energy Commission, the "engineering difficulties associated with breeding are enormous."

Some of the difficulties, it is pointed out, might be met by having one type of reactor designed to specialise in breeding fissionable materials, but also producing some power, and another, which, while specialising in producing power, could also produce new fissionable substance. The authors conclude, no doubt wisely, that the best course is to base their analysis on the assumption that nuclear reactors will make at least enough new fissionable substance to replace the fuel consumed in producing their energy output; though the reactor balance sheet will need to bear the cost of the fissile material needed to start operations. But it is hoped that the rate of breeding may suffice to take charge of the probable rate of growth of the new industry of producing atomic energy for civil purposes.

Difficulties also arise in the choice of materials for constructing the reactors. The normal engineering materials, steel, aluminium, and so on, are almost all unsuitable for one reason or another—most often because of their ready absorption of neutrons. Finding others which shall be free from these objections and yet have good structural qualities, as judged by ordinary engineering practice, is no light task and seems to grow no less with the passing years—hence the much longer space of time allotted to development work by those who are the best judges in such matters. On the other hand, the ever-growing demand for coal, its rapidly increasing cost, and the general difficulty of getting recruits for the mines, makes the need for an alternative source of energy all the more pressing. It is mentioned (see footnote on page 67 of the book) that an American observer visiting a British coal-mine asked "the fathers among those leaning and crouching around me—there was no room to stand—whether they wanted their sons to take up mining" and received the answer of an emphatic "No!"

On the subject of the application to existing industry the writers conclude that, whilst the manufacture of chlorine and caustic soda affords an instance in which the coming of nuclear power would not be expected to bring about a change either in location or process, with iron and steel both location and process might be changed through the substitution of electrolytically produced hydrogen for coke. Changes in process might come about in the instances of cement, brick and flat glass manufacture, as well as in phosphate fertilisers and in schemes of residential heating; whereas with aluminium there would probably arise a change in location, but not in the form of process. For railway locomotives nuclear energy is thought to have little chance unless the reactor with its requisite safety shielding could be made so compact that it would pass through a door 10ft wide and as much in height; it is plain, therefore, that plants suitable for stationary or marine work might prove entirely unsuited to locomotives.

In any strict accountancy, no doubt, the cost of supplying atomic energy for civil purposes should include a proper allowance for overhead charges incurred in the original work of development, but being undertaken for a military purpose these costs are customarily written off as war expenditure. This gives the civil aspect of the industry an easier start than it would otherwise have had, and it seems in consequence that the cost of deriving electric power from nuclear energy may not after all be very different from that of obtaining it from coal. That is not to say that the various items of the cost account will not themselves be very different; thus the cost of fuel transport is high for coal and almost negligible for atomic fuel, but, on the other hand, the steam boilers used in coal-burning plants are cheap to build and operate, whereas the nuclear reactors are likely to be expensive to construct and both costly and troublesome to run. But however similar the total of the running costs may be, the advantage in one country may be very different from that in another. In former days it was of great advantage to have a good supply of coal near at hand since the cost of haulage was then so much less. With nuclear fuel the equivalent supplies can be brought long distances at very low cost, always assuming that the country of origin is willing to allow export. In backward areas the lack of easy transport may give such an advantage to the use of this almost weightless fuel, that there may be a very great contrast indeed between the merits of the two. The authors make a great point of the importance in backward countries that any process of industrialisation they adopt should proceed with rapidity, since it is then likely to be accompanied by a fall in the birth-rate sufficient to enable higher living standards to become firmly established—without this there may be such an increase in the population as to swallow up the whole of the increase in productivity arising from such industrialisation.

It luckily happens that the elements uranium and thorium are abundant in the rocks of the earth's crust; the chief difficulty in the way of getting good supplies of uranium is that it is mostly so thinly distributed that it becomes very costly to extract from the parent rock. Though there are areas, such as the Belgian Congo, where relatively rich pockets are to be found, when the cost of extraction is vastly less. Needless to say, there has been a very close search made in recent years for similar rich deposits in other parts of the world, but the results of such prospecting work are rarely disclosed. And even when found their value

must depend to a considerable extent on there being a relatively settled and honest government operating in the area concerned, so that there may be adequate security for the plant and for those that work it.

That this exploratory study is the first comprehensive approach to one of the most important and controversial subjects faced by economists to-day is the claim made by those responsible for the book, and the reviewer regards the claim as fully justified.

Physics. By S. G. STARLING and A. J. WOODALL. London: Longmans, Green and Co., Ltd., 6 and 7, Clifford Street, W.1. Price 42s.

THIS book will be regarded with great interest by many who, like the reviewer, were brought up in close association with Mr. Starling's earlier works. In the present publication the authors, Starling and Woodall, have set out to cover the requirements of candidates for physics as a subject in a pass or general honours degree, starting from intermediate level.

In a brief review, such as this, it is possible only to comment on a few general points. The syllabus includes mechanics, heat, light, sound and electricity. Broadly speaking, the material is developed in historical rather than logical sequence. This procedure is a wise one; the manner and order in which concepts and theories have arisen naturally in their discoverers' minds is often more acceptable to students than the logical approach, though the latter may appeal to the more mature research worker.

Certain specific inclusions call for comment. An excellent straightforward chapter on statistical mechanics is presented, as a finale to the section on heat. The section concerned with electricity starts with the inverse square law and proceeds conventionally; however, it is good to see that unit magnetic poles are dismissed as non-physical. The C.G.S. system of units is used throughout and the M.K.S. system is referred to only in a brief paragraph; unfortunately, the rationalising of this system, which is perhaps its main justification, is ignored. The hundreds of diagrams included are very clear and illustrate essentially experimental treatment of the subject matter.

But it is only fair to point out that this book weighs over 4 lb, a fact which will be fully appreciated by the travelling student. In spite of the possible increase in price it might have been better to have divided it into four volumes. The size of the book might well have been reduced by omitting certain sections. Thus, what purpose is served by including the introductory short chapter on mathematics? And the section on musical instruments? Some of the tables could well have been omitted; surely all students possess log, sine and cosine tables. These, together with the Greek alphabet and the table of standard wire gauges, &c., unfortunately savour of padding, and a book of this scope and size certainly requires none.

Letters to the Editor

We do not hold ourselves responsible for the opinions of our correspondents)

W.R. GAS TURBINE LOCOMOTIVE

SIR,—It seems a rather notable circumstance that there is not contained in Mr. Nock's interesting article on the Western Region Gas Turbine Locomotive, reported in your issue of July 13th, a single word about the thermal economy of this engine. The catastrophic shortage of fuel from which this country suffers at the present time induces much discussion, informed and otherwise, on the subject of attaining greater fuel efficiency and, when I read the extremely frequent references to this subject, both in the technical and daily Press, I always feel surprised that the ghastly inefficiency of the steam locomotives, which still haul, I suppose, well over 90 per cent of our rail traffic to-day, is not more often emphasised.

At the end of the last century, when I was employed at the G.W.R. Works, Swindon, the percentage of useful work from the coal burnt in the locomotive boilers of that day converted into drawbar pull at the wheels did not exceed 5 to 7 per cent, depending upon the type of engine employed and its condition, and although I am not up to date in modern locomotive practice, I do not think that I should be very far wrong in stating that there has not been a gain of a full 1 per cent in those figures in the intervening half-century. There is plenty of room for research into fuel economy in this most highly inefficient application of coal-consuming equipment and, to me, it seems extraordinary that railway authorities here and abroad seem to devote so little attention to the fuel consumption aspect of new designs of locomotives.

C. ATHERTON ATCHLEY

London, W.1, September 4th.

DESIGNERS' FORMULÆ

SIR,—I have only recently had the opportunity of reading Dr. Tuplin's interesting article, "Designers' Formulæ," in your issue of August 3rd last. It has great value for young designers and is very necessary in these days of increasing world competition. Simple reliable formulæ devised by experienced men in their own fields of operation are very valuable.

Dr. Tuplin has pointed out the desirability of using British Standards for the good design features they incorporate, and for easing manufacture. He has clarified some misconceptions in gear design and touched on the necessity for correct appreciation of stress conditions. Other subjects occur to one which call for similar treatment. To name only a few: the reasonable use of tolerances; the essential requirements of materials for different jobs with suitable or perhaps desirable alternatives to those we are in the habit of using; the fundamentals of friction in mechanisms, conditions within their limits of sliding, and conversely their use in locking and non-reversible applications.

The gift of lucid exposition is not always possessed by those with most to give. It may be very much against their inclination to blossom into print, but if they are prepared to overcome this reluctance and make the necessary effort, and generous enough to give their knowledge to all and sundry, it would inject a great impetus into their country's industrial life and be a valuable contribution to its economy.

W. H. C. STARK, B.Sc., A.M.I.Mech.E.

Shenfield, Essex,
September 6th.

THE SAMPLE SIZE FOR A QUALITY CONTROL CHART FOR PROPORTION DEFECTIVES

SIR,—I assume the writer of a letter under the above heading in your issue of August 24th realises that his formula for control limits can only be applied when the number of defectives expected in the sample is greater than ten. This is implied by the fact that the two examples he quotes demand sample sizes of 364 and 865 respectively.

If control chart techniques are used on the factory floor to direct attention to deterioration in processes before they have become technically or economically important, then the use of such large samples involves too long periods of time, except when the testing procedure is of the simplest kind and the production rates high. The more usual practice recommended in this country is to select samples of ten to thirty at intervals which depend upon the production rate and general experience of the nature of the disturbances to which the process is subject. The test limits are usually adjusted to yield about two defectives per sample selected from the usual and acceptable standard of the product. In this case a suitable limit for the chart lies between four and five. The actual value of the limit, however, is less important in practice than watching the distribution of the points plotted about the average value expected. Any tendency for repeated points to lie above this level should promote technical action to correct the process.

If the supervisory staff, using the control chart method for small samples, make a practice of compounding the results of a number of small samples, then the procedure suggested by the writer of the letter can be of practical value in estimating how bad the product which has been made might be.

BERNARD P. DUDDING

Research Laboratories,
The General Electric Company, Ltd.,
Wembley,
September 4th.

American Agricultural Machinery

A REPORT entitled "Productivity in Farming," which has been published this week by the Anglo-American Council on Productivity, devotes one of its chapters to the development of farm machinery in the U.S.A. It says that the bulk of agricultural machinery manufacture in the U.S.A. is concentrated in the hands of comparatively few firms, but is, nevertheless, highly competitive. Large firms producing for large markets are able to devote considerable funds to basic research and machinery development and they are able to employ advanced and expensive research techniques, both in the laboratory and in the field. The report has been prepared by a productivity team which visited the U.S.A. last Autumn. Members of the team visited various university colleges during their tour and noted that all of them had large and well-equipped agricultural engineering departments. The report says, however, that in general the emphasis in those departments is upon instruction in the use and maintenance of existing machines. But there were some instances where the team saw work being done on the adaptation and modification of machines, although it was evident that general basic research and development of new machines is looked after by commercial interests. The report also mentions the use of electricity in American agriculture. More than 85 per cent of the farms of the U.S.A. are said to be supplied with mains electricity. Electrification, the report comments, is revolutionising the work in and around farm buildings and is increasing immensely the amenities of rural domestic life. It is suggested that the American methods of bringing electricity rapidly and efficiently to the countryside might well repay further investigation.

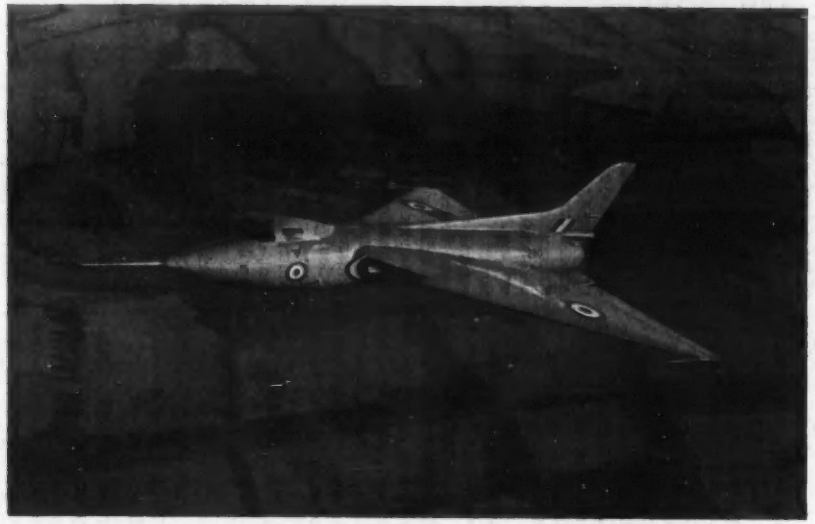
BOOKS RECEIVED

The Design of Prismatic Structures. By A. J. Ashdown. London: Concrete Publications, Ltd., 14, Dartmouth Street, S.W.1. Price 8s.

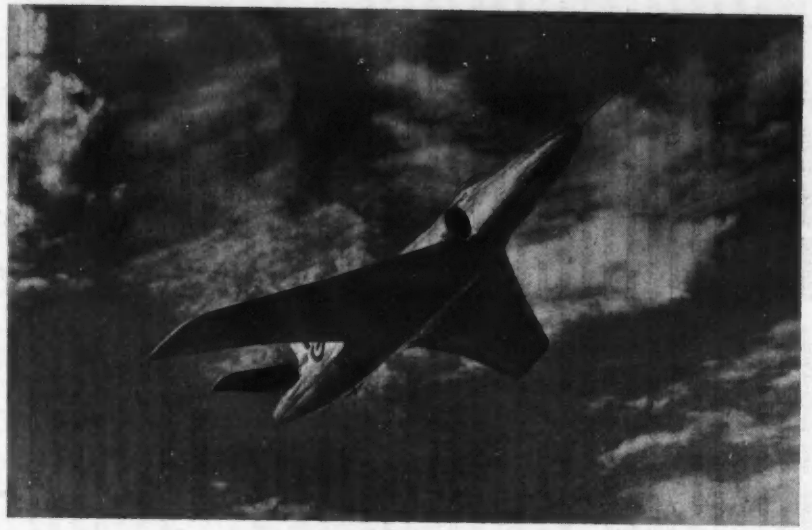
Industrial Polishing of Metals. By Gerald F. Weill. London: Iliffe and Sons, Ltd., Dorset House, Stamford Street, S.E.1. Price 21s.

Modern Bridge Construction. By F. Johnstone Taylor. Surrey: The Technical Press, Ltd. Gloucester Road, Kingston Hill. Price 30s.

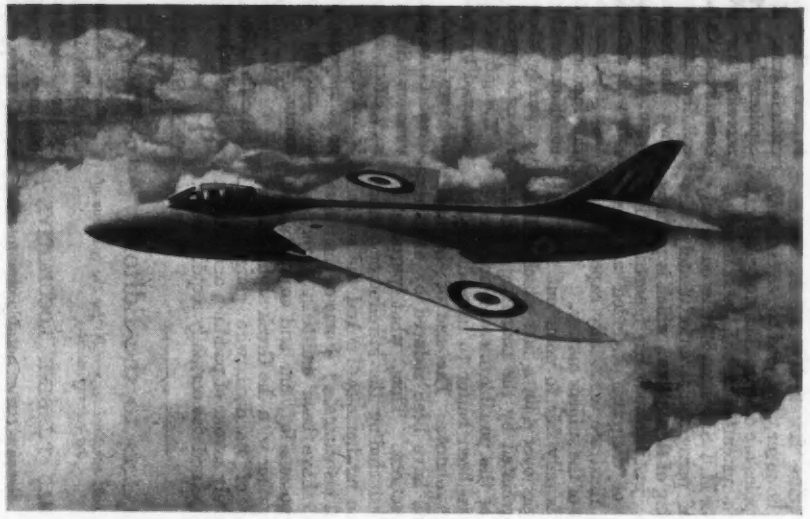
SOME MILITARY AIRCRAFT AT THE TWELFTH S.B.A.C. DISPLAY



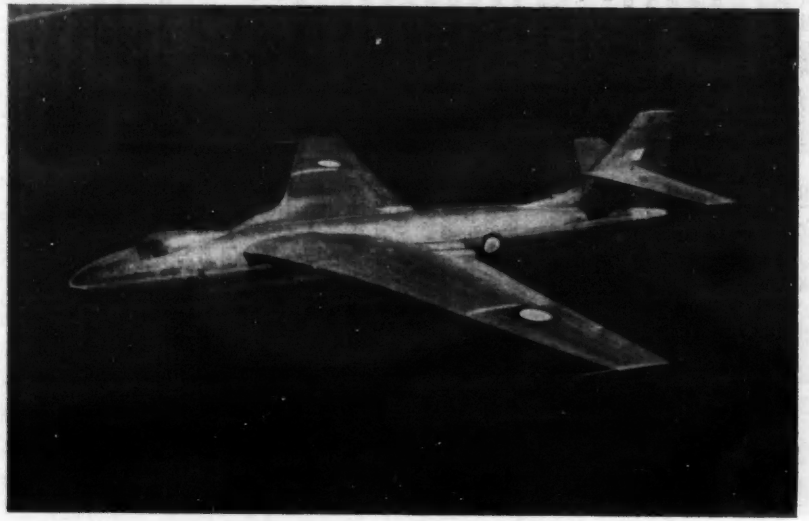
AVRO DELTA "707A" RESEARCH AIRCRAFT



VICKERS SUPERMARINE "SWIFT" FIGHTER



THE HAWKER "P1067" FIGHTER



VICKERS "VALIANT" FOUR JET BOMBER

The S.B.A.C. Flying Display and Exhibition

No. I

THE twelfth annual flying display and static exhibition organised by the Society of British Aircraft Constructors is once again in progress at the airfield of the Royal Aeronautical Establishment, Farnborough, Hants. The show was officially opened to guests of the Society on Wednesday, but the previous day there had been a preview arranged for technicians and the Press. To-morrow and on Sunday the general public will again be admitted and during the afternoons the flying programme will be augmented by a Royal Air Force display.

Several of the prototypes which have in previous displays aroused particular comment, had this year reached production status. In fact, in contrast to those displays, apart from certain pure research aircraft, all but four of the fifty-two aircraft exhibited are now in production. In most cases stringent security restrictions apply to these machines and no performance details are available. Mention may be made, however, of the high degree of sweepback, the low-aspect ratio, the much reduced thickness/chord ratio, and the relatively large wing areas which can be observed on some of the high-speed military aircraft which we illustrate. These characteristics can be fairly simply identified in the theoretical analysis of high-speed wing design. However, the manner in which high-speed aerodynamic factors are combined in any one wing structure is finally conditioned by weight and structural considerations, by the nature of the aeroplane and its required speed range.

Whether the aeroplane be capable of high subsonic or supersonic speeds it must also be able to land and take off with reasonable low flying speed characteristics. The highly swept-back wing had hitherto exhibited poor flying characteristics at low speeds.

Research has shown that its performance at these speeds is affected by the relation of the aspect ratio to the degree of sweepback adopted. As a result of tests on a number of wing plan forms A. V. Roe and Co., Ltd., has compiled a graph of sweepback versus aspect ratio which indicates that there is a limiting value of aspect ratio for a given degree of sweepback. Beyond this limit instability at the stall becomes manifest. The curve obtained indicates that for an unswept wing almost any aspect ratio can be accepted and for wings of 45 deg. sweepback an aspect ratio of little over three is the most satisfactory.

As a consequence of this relation it is stated that the once dangerous slow-speed characteristics of swept-back wings can be relatively easily avoided. This consideration is a most important one, for these machines must eventually be flown, as were their predecessors, by quite inexperienced pilots.

Military Aircraft

Perhaps the most outstanding machine at Farnborough this year is the first British multi-jet bomber, the Vickers (Weybridge) "Valiant," which first flew in May 1951, and is now in production. Our illustration of this advanced shoulder wing bomber design clearly shows the sweepback adopted on both the main wings and the tail planes. The fin is also tapered backwards, with the elevators placed high to clear the wing wake at high speeds. The wing root profiles each enclose two Rolls-Royce "Avon" jet turbines which are closely mounted and share a common narrow rectangular inlet grating along the leading edge, the arrangement constituting perhaps the "cleanest" buried power installation in any multi-engined machine to date. The machine has a tricycle undercarriage, the main legs having paired wheels in tandem.

Different in many respects is the Short SA/4 four-jet bomber, made by Short Bros. and Harland, Ltd. Its four "Avon" engines are arranged vertically in pairs on each wing, each pair sharing a nacelle which is slightly inclined upwards to the longitudinal axis of the aircraft. It has a broad tapered thin wing, but there is an absence of sweepback on all surfaces. The tail planes are mounted much lower than on the "Valiant" and are mounted with dihedral. The undercarriage main legs have wheels in tandem.

The "Canberra" twin-jet machine, made by the English Electric Company, appears to occupy the role within the jet range of military aircraft, once played by the de Havilland "Mosquito" in the last war. It is now being produced in three versions, all of which are fitted with the Rolls-Royce "Avon" axial-flow jet turbine. The first mark of this engine developed 6500 lb static thrust at sea level.

The Mark 3 version of the Canberra, which is appearing in the display, is a photographic reconnaissance aircraft, equipped for operation at high speeds and great heights. The fuselage is 14in longer than that of the Mark 2 tactical bomber. The transparent nose resembles that of the Mark 2 tactical bomber, but does not embody the optically flat bomb aimer's panel. A "Canberra" fitted with "Sapphire" engines is entered in the display by Armstrong Siddeley Motors, Ltd.

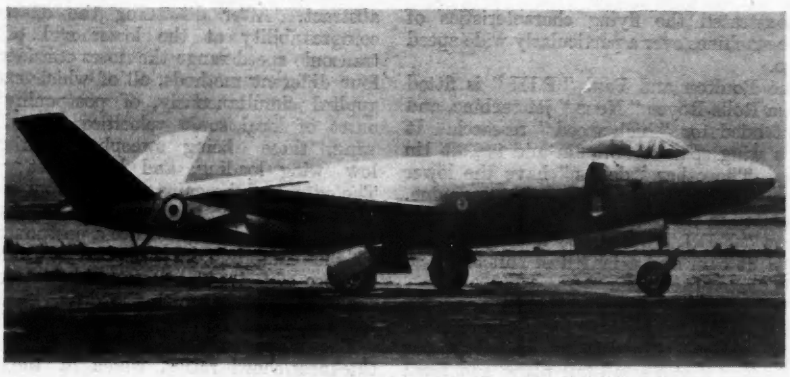
A notable experience for visitors to Farnborough is always provided by the hign-speed runs of the jet fighters made alongside and within a few yards of the spectators' enclosure and at head height. Special interest this year attaches to the performance of the two interceptors which are now being produced in quantity by the Hawker Aircraft Company and by Vickers-Armstrongs, Ltd. Unfortunately the Vickers "Swift" has been damaged and could not appear, but the Hawker P1067 made the fastest run seen at any Farnborough display.

The general outline of the Hawker P1067 machine is somewhat similar to the prototype aircraft developed by that company, and particularly to the P1081, which was demonstrated last year. It is the first of its series to have an "Avon" engine in place of the customary Rolls-Royce "Nene," which has smaller thrust and a centrifugal compressor. The air intakes are housed in the wing roots and the jet pipe exhausts through the tail. Both main and tail planes are swept back. The fin also tapers backwards and carries the tail planes.

This aircraft has been officially quoted as the fastest known fighter in the world. Another version of this machine, the P1072, has been fitted with a bi-liquid fuel rocket motor in the tail, in addition to a "Nene" engine which exhausts through twin jet pipes at the rear wing roots. This unit develops 2000 lb static sea level thrust and can be used when required by the pilot for periods at his control.

The Vickers (Supermarine) "Swift" is similarly a development of the "Type 535" demonstrated last year, the development of which can be traced as far back as the "Spitfire." Towards the end of the war, when the need for jet fighters became apparent, the near-elliptical wing forms designed for the "Spitfire" were fitted to a fuselage accommodating a Rolls-Royce "Nene" jet engine, and became the "Attacker," now in production for the Royal Navy.

The development work on the "Attacker" continued with the building of the "Type 510" research aircraft, which was the first British aircraft with all surfaces swept back. This aircraft, which is designed with a greater degree of sweepback than any contemporary British machine, has put up some outstanding demonstrations of speed and manœuvrability since it first flew in December, 1948. The later "535" machine was a developed fighter version, modified to accommodate a tricycle undercarriage, and the rear fuselage adapted for a reheat installation. The engine specified was the Rolls-Royce "Nene."



VICKERS "508" TWIN JET NAVAL FIGHTER

Air brakes were fitted to allow greater flexibility for combat and the armament was composed of four 20mm guns. In the "535" the armament is carried in the wings, but in a production version the guns could be enclosed in the fuselage. The span was 31ft 8½in and the length 42ft 11in.

The "Swift" can hardly be distinguished externally from the type "535," but an "Avon" engine again replaces the "Nene" used on all its former prototypes.

The second Vickers Supermarine machine to make its first flight recently is a new naval twin jet fighter the "Supermarine 508." This machine is expected to exhibit outstanding flying characteristics over a very wide speed range. The manner in which the two

Avon " jet turbines are housed within the fuselage may be seen in our illustration. The unusual tail arrangement may be noted in which the rudder and fin are dispensed with and the tail planes set with dihedral.

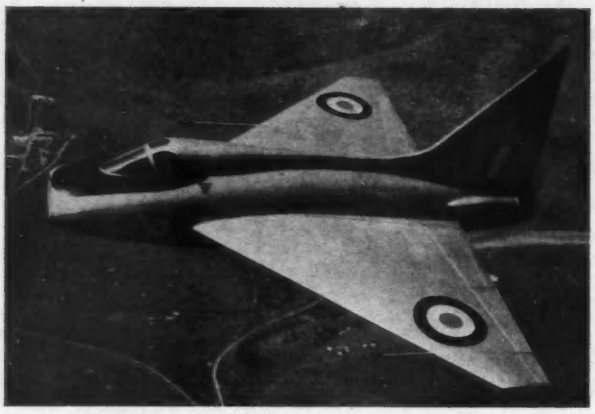
Considerable flight experience has been obtained during the last twelve months with the delta wing tailless aircraft, and four different versions are now flying. Participating in the display are the Boulton and Paul " P 111," illustrated below, and the Avro " 707 B " delta aircraft, which long, the 34ft 2in span of the " 707 A " being 1ft 4in longer than the " 707 B."

A. V. Roe and Co., Ltd., regard these two aircraft not as military prototypes, but as scale models of large transport aircraft which they envisage as the most advantageous design for cruising speeds up to a Mach number of 0·9. In connection with the work on its delta project, J. R. Evans, the chief aerodynamicist of A. V. Roe and Co., Ltd., has prepared some notes on the aerodynamics of delta aircraft of which the following is an abstract. After discussing the effects of compressibility at the lower end of the transonic speed range the notes consider the four different methods, all of which can be applied simultaneously, of postponing the onset of local sonic velocities around the wing, these being sweepback, thinness, low wing loading, and low-aspect ratio. The extent of the gains possible from sweepback is very considerable, and sweeping a wing back may easily lead to a postponement of the compressibility effects by a Mach number of 0·1. The illustration (*a*) below shows the way in which the drag rise Mach number is increased by the sweepback.

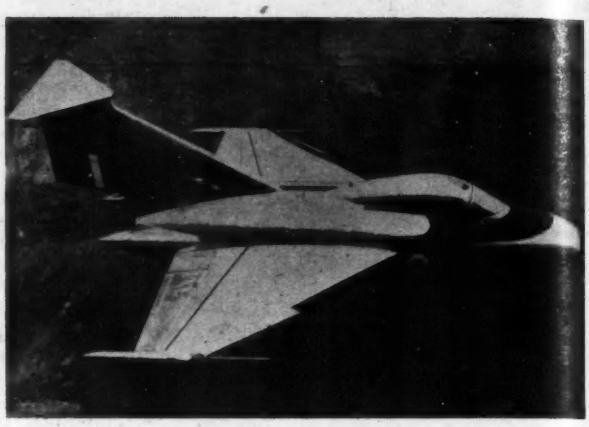
The notes indicate the reason for low thickness/chord ratios, which in the past effects is given by reducing aspect ratio. This is shown in diagram (*c*). Apart from the desirability of low-aspect ratio for stability reasons at the stall, the notes quote a further reason for choosing a low aspect ratio. Compressibility effects are minimised and a transition from speeds below that of sound to the speed of sound and above is much more readily accomplished if the aspect ratio is low, say, of the order of 2 to 4.

A little consideration of geometrical properties and possible plan form of wings leads to the conclusion, the notes continue, that the delta wing is the only form which satisfies these requirements. It possesses high sweepback and low-aspect ratio. The wing area will, of necessity, be generous for the size of the aircraft and for reasons which will be detailed later, it is easy to build it with a low thickness/chord ratio.

It is next shown how the delta plan form, indicated from considerations of aerodynamic performance, lines up with practical design requirements. A preliminary question is whether a tail plane is necessary. Investigation shows that a control surface at the trailing edge of the wing, provided that the latter has a large root chord (as has the delta), can cater for all but the extreme



THE BOULTON AND PAUL " P 111 "

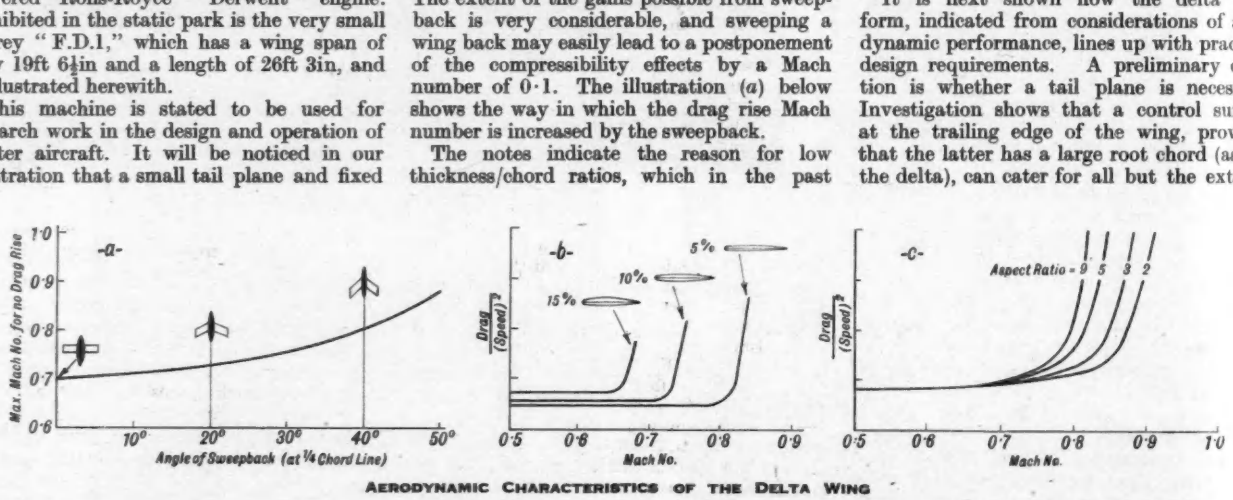


THE FAIREY " FD1 "

demonstrated the flying characteristics of these machines over a particularly wide speed range.

The Boulton and Paul " P III " is fitted with a Rolls-Royce " Nene " jet turbine, and is intended for " high-speed " research. It has a wing span of 33ft 6in and is 26ft 1in long. The other " deltas " have the lower powered Rolls-Royce " Derwent " engine. Exhibited in the static park is the very small Fairey " F.D.1," which has a wing span of only 19ft 6½in and a length of 26ft 3in, and is illustrated herewith.

This machine is stated to be used for research work in the design and operation of fighter aircraft. It will be noticed in our illustration that a small tail plane and fixed



AERODYNAMIC CHARACTERISTICS OF THE DELTA WING

wing tip slots are fitted as a precautionary measure for the early flight testing. Air brakes and wing tip parachutes are fitted to deal with flight emergencies, and a central drogue parachute is installed at the rear end of the fuselage to relieve the wheel brakes during the pull up after landing. Flying controls take the form of " elevons " and rudder.

A. V. Roe and Co., Ltd., is demonstrating its " 707 B " machine, from which has been developed the type " 707 A," said to be capable of higher speed research. In the " 707 A " version wing root air intakes have replaced the dorsal intake, the efficiency of which on the " 707 B " was said to have suffered from the turbulence caused by the pilot's canopy. Both machines are 33ft 4in

have ranged from 21 per cent down to perhaps 12 per cent. Now values of 10 per cent down to 7 per cent are becoming common. An indication of the result gained is given by the illustration (*b*).

By supporting the weight of the aircraft with a large wing area Mach number effects are postponed. This condition is particularly important for flight at high altitudes where the low air density puts a premium on keeping the wing loading low. In fact, flight at high altitudes becomes virtually impossible unless this is done.

For moderate speeds a high-aspect ratio, i.e., a large span relative to the chord, gives greatest efficiency. At high Mach numbers this consideration is no longer important ; in fact, some alleviation of compressibility movements of the centre of gravity.

To deal with trim changes due to landing flaps, &c., with the low wing loading associated with the delta wing, take-off and landing speeds are moderate without the use of flaps, and this question does not, therefore, arise. The reduction of damping of the pitching oscillation has led to difficulty on some tailless aircraft, but it does not arise on the delta, since the large chord near the root gives adequate damping.

An aircraft with a high aspect ratio sweptback wing would need a tail plane to deal with aeroelastic distortion at high speeds, but the shape of the delta wing makes it extremely stiff, both in bending and in torsion, and a tail plane does not appear necessary.

Although it has not been proved, it is expected that the controls on a tailless delta wing would not be powerful enough to ensure recovery from a fully developed spin. A tail plane appears to be the only way of dealing with this. This restriction is of no significance for transport or bomber aircraft for which spinning does not arise.

Because of its shape and the large root chord the delta wing provides a large internal volume in relation to its surface area, even when using the thin wing sections. If the inboard half of the wing only is considered, as this represents a more practical case from the point of view of the aircraft designer, the internal volume of the delta wing is more than twice that of the corresponding untapered wing.

It is found that without exceeding a wing thickness of as little as 8 per cent to 10 per cent it is possible on a moderate-sized delta wing aircraft to bury completely the engines, undercarriage and sufficient fuel tanks for a very considerable range. The fuselage also has a tendency to disappear into the wing at the root. The result is the attainment of an aircraft consisting only of a wing, a fin and a rudimentary fuselage. In fairness, it must be pointed out that this is achieved at the expense of a rather larger wing area than usual, but investigation shows that the drag of this is considerably less than that due to a conglomeration of items such as engine nacelles, tail plane, &c.

From the design point of view the shape of the delta wing leads to an extremely stiff structure without the use of thick wing skins, and strength becomes the determining factor rather than structural stiffness. This avoids the inefficiency of conventional swept-back wings where the wing has to be made stronger than necessary in order that it shall be stiff enough. The notes conclude by saying that the delta wing lends itself to conventional design techniques, and to conventional methods of construction.

There were, of course, other military aircraft displayed whose previous performance at Farnborough will be remembered. These included the de Havilland "Venom" and "Vampire" aircraft. The "Venom" has a thin wing incorporating sweepback on the leading edge only. A de Havilland "Ghost" centrifugal flow jet turbine of 5000 lb static thrust is fitted. Versions of this aircraft in service include the "FB1" fighter bomber, the "Venom 2" night fighter, and the "Sea Venom," which is slightly modified for naval operations. There is also the Fairey "Gannett" carrier-borne anti-submarine machine, which is now in production. It is fitted with a double "Mamba" installation driving independent coaxial propellers and drives from this arrangement the virtues of a twin-engined aircraft, but having perfect thrust symmetry on one engine. It normally cruises on one engine, which then operates under near-optimum conditions, employing both halves of the installation only for combat, landing and take-off purposes. A new version of the "Meteor" is shown, carrying tactical armament and equipment consisting of four 20mm cannon with twenty-four wing-mounted 95 lb rocket projectiles and two 100-gallon wing tip tanks. Loaded in this manner it demonstrated several protracted spinning manœuvres. A "Meteor" fitted with "Sapphire" engines was again demonstrated. This aircraft recently climbed to 39,370ft in 3 min 7 sec, during which climb it maintained a Mach number of 0·78 whilst flying at an angle of 40 deg. There is also "Lincoln" flying test bed, this time equipped with a Napier "Nomad" composite engine.

Guided Missiles in Sea Warfare

(By our Naval Correspondent)

THE impending departure for Australia of a team of rocket experts to take part in missile tests on the Woomera rocket range is a reminder of the progress that has been made since the war in the development of supersonic missiles and projectiles. Extensive research has been carried out in Naval Ordnance Test Stations and Laboratories in the United States in connection with the resistance encountered by fast-flying bodies, with particular reference to the rise in temperature, friction and suction at the base end of the missile. At even the relatively low supersonic speeds achieved up to date the increase in temperature may amount to several hundred degrees Fahrenheit near the surface of the missile and, with the prospect of much higher speeds to come, the design of the missile must provide for the protection of the explosive from premature detonation and for the suitable location of the guiding and other delicate mechanism to prevent damage from overheating.

Guided missiles may be defined as missiles which are directed to a target either by means of mechanism inside or by instruments situated outside them, and they vary in type according to the location of the target and the launcher. Thus, guided missiles launched from a platform aboard ship or on land against a surface target are known as surface-to-surface missiles and they are of two categories—the rocket and the winged missile. The rocket carries its own oxidiser, travels beyond the atmosphere, is supersonic and has a parabolic trajectory. In appearance it may be compared with the German V.2. The winged missile carries its own fuel, but uses atmospheric oxygen for burning the fuel. This jet-driven missile is restricted to flight in the atmosphere and is much slower than a rocket and thus more vulnerable to counter measures. Both kinds are suitable for long-range bombardment and for firing from surface ships or submarines. The United States has, indeed, already developed a 12,000 lb rocket which can be guided throughout its trajectory and may well be the projectile for the main armament of the two rocket-firing cruisers now to be constructed for the United States Navy under the recently approved naval building programme. Guided self-propelled winged missiles, with a reported range of 500 miles, have been fired experimentally with promising results. Strict secrecy is from U.S. surface ships and from submarines maintained regarding the methods and instruments employed for guiding the missiles, but for internal guiding mechanism to be used successfully the target must clearly have some characteristic feature which distinguishes it from the background—such as a ship at sea—and is thus "recognisable" to the target-seeking instrument, while external guiding mechanism presupposes an accurate knowledge of the position of the target.

These large surface-to-surface missiles may well ultimately replace the shell as the projectile fired from the primary armament of surface ships, but this must depend on the accuracy of the guiding mechanism and, in view of the space required for carrying a worthwhile number, on the practicability of fitting them with atomic warheads.

Other kinds of guided missiles are the surface-to-air (for anti-aircraft defence), the anti-submarine rocket, the anti-submarine homing torpedo launched either from surface ships or submarines, the air-to-air rocket, and the air-to-surface missile. The surface-to-air guided rocket is now in advanced stages of development in the United States and a year ago the then chief of the U.S. Navy Ordnance Bureau stated that it would greatly increase the fleet's power to cope with attacks by the latest types of aircraft. General Collins, the Chief of Staff of the United States Army, is even more definite and asserts that these anti-aircraft rockets will be able to destroy planes at altitudes above 60,000ft. It is not intended that they should replace anti-aircraft guns which will probably always be most effective against low-flying targets. But conventional artillery alone is no longer able to cope with the modern high-altitude bomber with supersonic speeds and much improved manœuvrability.

Little is known about the anti-submarine rocket apart from the fact that the United States Navy has developed a shipboard launcher capable of firing these rockets at a high rate. The homing torpedo, an early edition of which was used by the Germans in the last war without much success, is being developed both in this country and in the United States for use against submarines and, though still in the experimental stage, has already given promising results. Guided by internal mechanism, it picks up the target and sets its own course.

The air-to-air guided missile, like the surface-to-air missile, is an outcome of the high performance of modern aircraft. As bombers and fighters approach and exceed supersonic speeds, aerial combat with conventional guns and rockets becomes almost impossible. The high-speed fighter has a very short time available to intercept an enemy bomber and may have no opportunity to make more than one attack. The air-to-air missile practically eliminates the human element. A radar picture makes clear to the pilot the moment and direction for launching the rocket which is thereafter automatically guided on the correct interception course and makes further attacks unnecessary. The new American air-to-air rocket, which, it is announced, has successfully passed its test for use in naval fighter and interceptor aircraft, is small enough to be carried in quantity in modern high-speed aircraft, has a much greater range and speed than aircraft rockets hitherto used and brings bombers under fire at a range beyond the latter's defensive power. There is, however, as yet, no official information that this new rocket has, in fact, been fitted with guided mechanism.

Improvements in anti-aircraft defence compel the bomber under modern conditions to drop its bombs from a very high altitude, which means inaccuracy. The need, therefore, exists for a bomb which can be released a great distance from the target with a good chance of hitting it. The air-to-surface missile is the answer. Two types are under development in the United States, in addition to the "Loon," which, though more strictly a surface-to-surface missile, can equally well be launched from and guided by a controlling aircraft. The original, unguided version was, indeed, launched by the Germans at night from aircraft from positions half-way across the North Sea, after the shore launching platforms in France had been captured by the advancing Allied Armies, but the damage done was negligible. The two basic types now under development are the controlled bomb and the glide bomb. The trajectory of the controlled bomb can be varied to obtain increased accuracy either by a built-in target-seeking device or by radio remote control from the launching aircraft. The second type—the glide bomb—has similar guiding devices, but is also fitted with wings which increase the range of the bomb, resulting in less exposure of the launching plane to enemy fire. The air-to-surface missiles should be very effective against ships and other clearly defined targets, which readily permit the use of automatic target-seeking devices. They are likely to be used most frequently in attacks carried out by a small number of planes against well-defended targets.

The effect of guided missiles on naval operations may well be profound in the event of war within the next few years. On the one hand, ship-launched surface-to-surface rockets—fitted in all probability with atomic warheads—will give warships, both surface and submarine, immensely increased offensive power. On the other hand, the air-to-surface missile against surface ships makes their anti-aircraft defence a problem of increasing difficulty when operating in enemy waters.

A MANUAL ON PRESTRESSED CONCRETE.—Stressed Concrete Design, Ltd., Lynton House, 54, South Side, Clapham Common, London, S.W.4, has recently published a booklet entitled: "Prestressed Concrete Manual." It describes the Magnel-Blaton system of prestressed concrete.

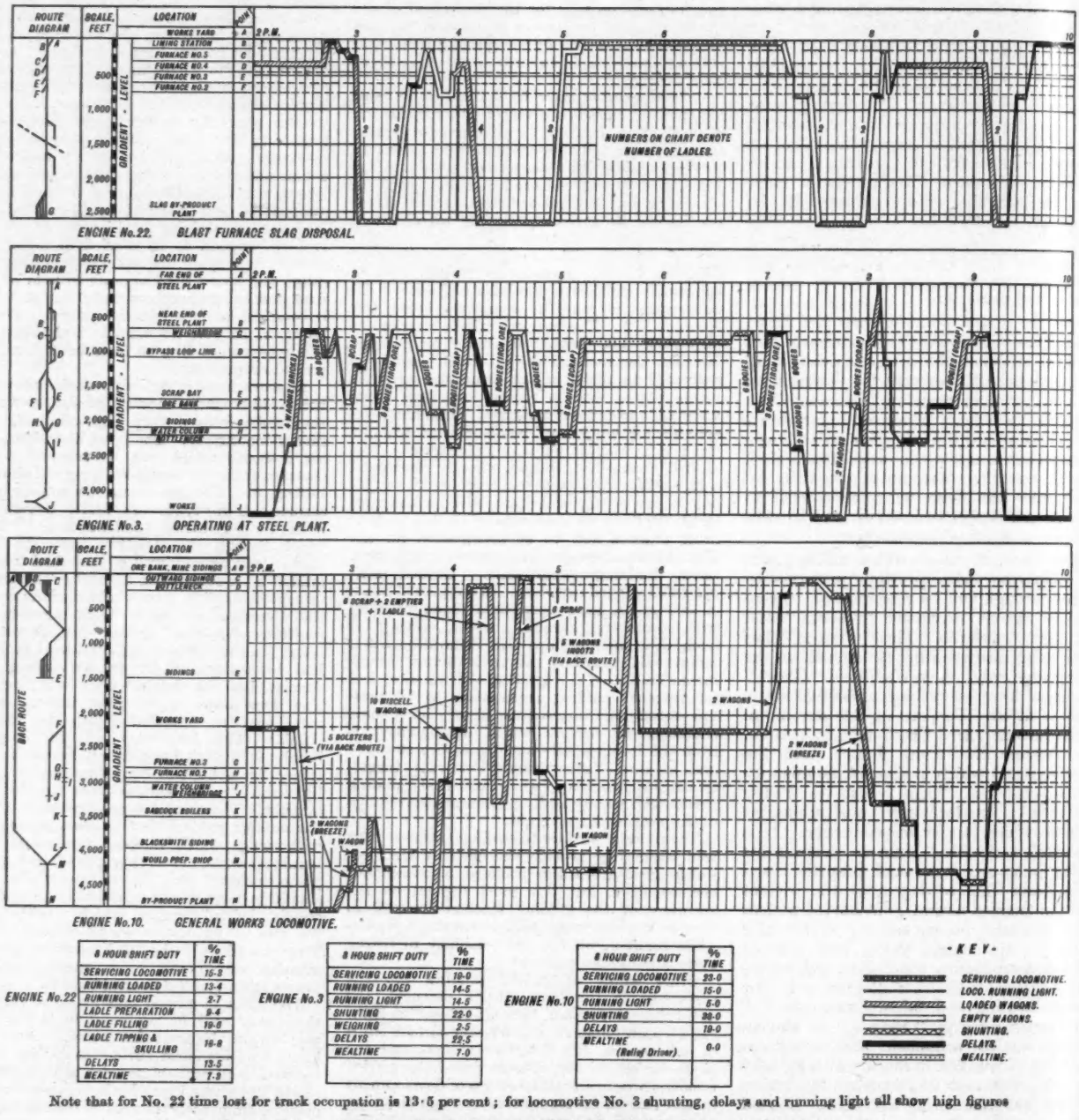
The Research Engineer in the Iron and Steel Industry

By FRANCES MORTIMER, B.A.*

THE great expansion of iron and steel output over the last three decades has enormously multiplied the problems of the industry's engineers. Adapting the physical structure of the industry so that it can cope efficiently with the new production schedules makes constant demands on their resources. Already a modern open-hearth melting shop may have to feed into its furnaces 12,000 tons of raw materials and to dispose of the same amount of finished and waste products weekly. New furnace designs and techniques such as single air uptakes, automatic roof temperature control, oxygen lancing and the use of all-basic furnaces tend to increase production per unit. Figures have recently been published, for example, showing how one automatically-controlled, all-basic furnace at Stewarts and Lloyds' Bilston works is producing 1233 tons of steel weekly, against 936 previously. Obviously this expansion places a severe strain on machines and space intended for a smaller scale of operation.

The men on the spot, the maintenance and development engineers, bear the brunt of the problems and, like their counterparts in other industries, have to be part theorists and part practical technicians. But the steel industry has discovered the value of the wider view, which can be provided by a central body set up to do co-operative research on the engineering problems of the industry as a whole. The plant engineering division of the British Iron and Steel Research Association, in existence for a little over five years now, has already completed a useful number of projects in the cause of improved engineering in this field. The division has four sections, corresponding to the division of engineering in the industry—mechanical, electrical, civil and fuel, but there can be no water-tight departments where research is concerned.

One of the first projects undertaken was a study of the lay-out of iron and steelworks. Many works had evolved necessarily with the appearance of a patchwork quilt. The industry appreciated the need for organising the different processes so that the great bulk of material flowing through the works could be handled logically, but the complete picture of how this should be done had not been available before. The arrangement of buildings so that each unit receives and consumes the products of the preceding one was recommended in a detailed report to the industry. But practical problems in



ENGINE No.22

8 HOUR SHIFT DUTY	% TIME
SERVICING LOCOMOTIVE	15·3
RUNNING LOADED	13·4
RUNNING LIGHT	2·7
LADLE PREPARATION	9·4
LADLE FILLING	19·5
LADLE TIPPING & SKULLING	19·8
DELAYS	13·5
MEALTIME	7·9

ENGINE No.3

8 HOUR SHIFT DUTY	% TIME
SERVICING LOCOMOTIVE	10·0
RUNNING LOADED	14·5
RUNNING LIGHT	14·5
SHUNTING	22·0
WEIGHING	2·5
DELAYS	22·5
MEALTIME	7·0

ENGINE No.10

8 HOUR SHIFT DUTY	% TIME
SERVICING LOCOMOTIVE	23·0
RUNNING LOADED	15·0
RUNNING LIGHT	5·0
SHUNTING	26·0
DELAYS	19·0
MEALTIME (Relief Driver)	0·0

- KEY -
SERVICING LOCOMOTIVE.
LOCO. RUNNING LIGHT.
LOADED WAGONS.
EMPTY WAGONS.
SHUNTING.
DELAYS.
MEALTIME.

Note that for No. 22 time lost for track occupation is 13·5 per cent; for locomotive No. 3 shunting, delays and running light all show high figures

FIG. 1—EIGHT HOUR SHIFT CHARTS FOR THREE STEELWORKS LOCOMOTIVES

*British Iron and Steel Research Association.

plant lay-out can only be solved in terms of individual works and the complexity of the details that must be taken care of make many steel firms reluctant to interfere with existing arrangements. While the research engineer's recommendations are accepted in principle, the costs of reconstruction and loss of production time weigh heavily against change. Often the real usefulness of engineering research is to provide a yardstick by which the engineers or management in individual firms can measure the efficiency of their operations. They can then start from first principles to design new plant or make the necessary modifications within the framework of existing plant. Traffic arrangement and control is a major factor in either case.

The idea of building a works around a railway system has now been generally accepted in the industry and most modern, fully integrated works are constructed on that principle, but in the older works the railway system grew with the plant, so that theory often lagged behind expediency. An investigation into wagon and locomotive use showed, among other things, that locomotives were rarely employed for more than half their time. As a locomotive costs around £1 per hour, whether usefully employed or not, some adjustments were obviously needed. A method of gauging traffic efficiency based on the speed of wagon turnround was developed and has since been successfully applied in a number of steelworks (Fig. 1). The possibility of speeding up traffic by improved communications was next investigated. This led to trials of mobile very high frequency radio communication between works locomotives and one or more central points in an integrated steelworks. Several firms are now using this equipment.

Studies of melting shop lay-out produced a number of new designs (Fig. 2) making use of welded and rigid structures planned to give improved lighting and reduced maintenance. As the lay-out of melting shops is controlled largely by the methods of charging the furnaces and handling the ingots, the engineers turned their attention to these operations. The effect of furnace stage traffic arrangements and the capacity of scrap handling cranes and box chargers upon the rate of charging was investigated. The plans for several new melting shops, which are part of the steel development plan, were studied by means of models and theoretical time charts and a basis for designing and operating such systems was worked out.

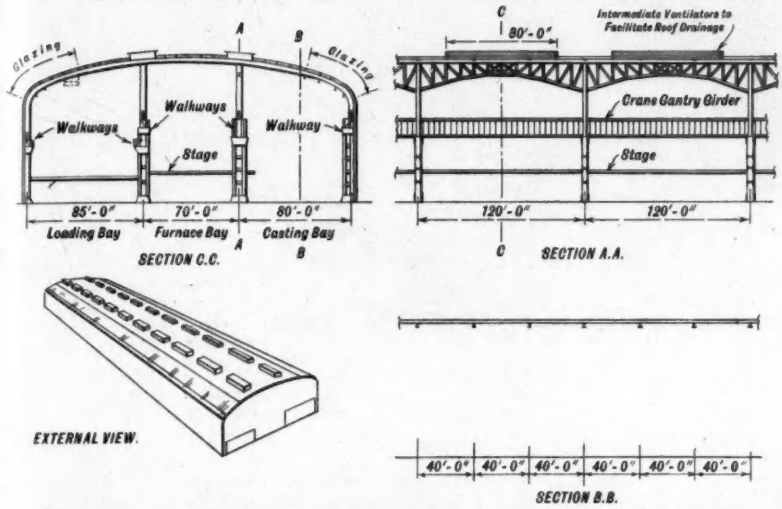
The first concern of the research engineer to-day is the development and practical application of new or improved techniques. To this, background research is an essential corollary if any long-term improvements are to be made. Unfortunately the engineers often have to defer their long term projects because of the pressing needs of the moment. For instance, the physical problems of steel scrap in bulk were studied as a means of assessing different methods of handling. Logically the next step should have been the development of alternative methods. Work was begun on a scheme for a high capacity bench-loading system, because it was apparent that if the rate of charging was to be increased to any great extent it would have to be by getting rid of the traffic bottleneck of scrap charging. But this had to be dropped in favour of the short term objective of increasing the scrap density in the pans used for charging.

Many examples can be given of engineering research, where the results can be directly applied in the industry. An important problem in blast-furnace charging is how to control the distribution of the ores and coke so that the gas flows through at a uniform rate, giving more economic reduction of the ores. The plant engineering division of the British Iron and Steel Research Association co-operated with the iron making division in the design and construction of models to give radial control of the burden at the furnace stockline. Two schemes are now available. A study of the principles used on different methods of gas cleaning, which now cost the industry as much as £1,250,000 a year, resulted in the development of a gas cleaning plant incorporating spinning disc spray generators (Fig. 3). This improvement is expected to cut down the water and power consumption considerably. Pilot plant is now being installed at a northern ironworks. Investigation also revealed that, provided there is a safe margin, water requirements of blast-furnaces and melting shops might be considerably reduced with consequent savings.

Further economies may be achieved through more systematic handling of the ingots from teeming to the mill racks. Time studies showed that the time lost in handling the ingots resulted in extravagant use of the soaking pits. A new system of movement has been suggested which may give an increase in soaking pit throughput without any increase in fuel consumption. Prototype surface pyrometers have also been developed for measuring ingot temperatures. They will help to advance the more fundamental studies of the changes of heat content and temperature distribution of the ingots between teeming and rolling.

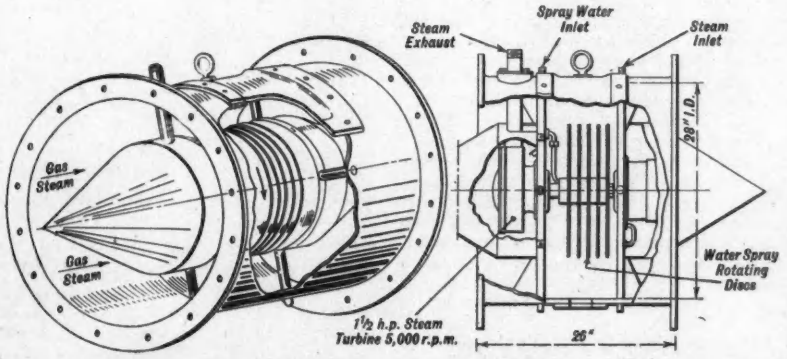
One of the most important of B.I.S.R.A.'s contributions to engineering development in the industry is a new specification for electric overhead travelling cranes, for use in iron and steel-works. For instance, these cranes have been in use for over forty years, but until recently travel motion performance was specified only in terms of speed, not of acceleration. But the top speeds specified were seldom obtained because the acceleration was not sufficient for the crane to reach its maximum speed in the average length of travel. The engineering division's recommendations on this point were based on an analysis of sixty-eight travel motions and a method of assessing travel motion performance which takes into account both the initial acceleration and the speed of the motions was evolved. Thus the purchaser can classify his own cranes and order new ones to the performance standard he requires. Increases in operating efficiency as well as in the rate of manufacture, because of greater uniformity of design, are expected. An extension of this work gave rise to a new design for the crane cab and master controller. Models have been built by control gear manufacturers to give vertical operation of the handle, short axial length and easy maintenance, features appreciated by the operators.

Recently, the division's efforts have been concentrated on the study of the handling of imported ore. Conditions during unloading of the ships at the wharves and the problems of transport and storage between port and



A proposed design of transverse-span arched roof over three bays supported on longitudinal continuous lattice girders

FIG. 2—MELTING SHOP DESIGN



Shortly to be installed for production-scale trials at Clyde Iron Works. (Colvilles Ltd.)

FIG. 3—EXPERIMENTAL GAS CLEANING PLANT

works stockyard are being studied. The rate of ore discharge at six ports has been analysed to discover the factors which affect the turnround time of ore ships. Mechanical methods for removing the last part of the ore from the holds are being examined, as this part of the work is slow and requires much manual labour. Tidal data at ten representative British ports have been assessed to find out how the size of ships using the ports compares with the estimated maximum size that could enter. This has shown that much larger ships could be used than are actually employed, if other conditions, such as chartering, were favourable. The suitability of various classes of ship for ore carrying is also being assessed by comparison of known performance figures in relation to ship design. This work may eventually serve as a guide for shipbuilders on the design of ore-carrying vessels. In the meantime the information is being used to prepare estimates of the operating costs of different types of equipment under a variety of circumstances.

The iron and steel industry presents a vast and heterogeneous field for future development. How far it can be handicapped by raw materials shortage remains to be seen, but at the present stage the opportunities for applied engineering research seem almost unlimited. For some years to come, as only a portion of the outstanding problems can be dealt with, the problems will have to be selected on the basis of the maximum increase in iron or steel tonnage or the maximum decrease in production costs to be derived from their solution. But some fundamental work will always have to be done. The engineer who is primarily interested in this kind of work should not dismiss this field as negligible. Rearmament has given new impetus to the problems already made urgent by the demands of an expanding export drive. More research must be done on the design, lay-out and operation of the plant which has to carry the weight of production.

The extent to which the industry can digest the new techniques and new equipment is a critical question, but the engineer is equally important from this aspect. Whether it is fuel technology or structural design, standardisation of motors or the use of servo-mechanisms, furnace design or control, he is responsible for discovering the means by which the technical advances can be assimilated in the works with minimum disruption of existing production programmes.

"Packaged" Power in Australia

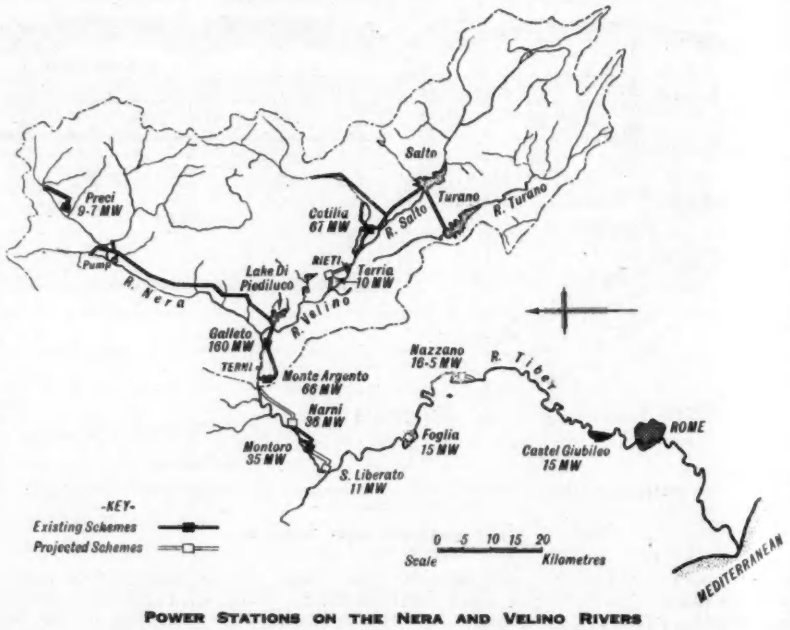
DEARTH of adequate electric power is handicapping industry in most Australian States. Shortage of coal because of industrial disputes is only one factor, although its gravity should not be minimised. There is an unprecedented demand for "emergency" power plants to enable factories to continue production and offices to have adequate lighting during the "black-outs," which are among the many anomalies which have reached their peak during the winter months. It seems that the market for such equipment should continue to be firm. Another aspect is the need for more power for industry on the mainland. Tasmania, the so-called "little sister" State, with its well developed hydro-electric system, is the exception. Until hydro schemes have been completed in Victoria and New South Wales, including such ambitious undertakings as the Snowy River project, Australia should remain a good customer for "packaged power." The State Electricity Commission of Victoria has placed orders for "packaged" power stations, whose aggregate output will be 60,000kW. They will be installed at four country centres at an estimated cost of £A.6,000,000.

The Monte Argento Hydro-Electric Scheme, Italy

THE Monte Argento power station, which generates power from the waters of the Nera River, came into operation last December. It forms part of a development scheme for the Nera and Velino basins, which is intended to exploit the water power resources of the two rivers comprehensively with a co-ordinated system of storage reservoirs and power stations. The various power stations in the catchments of the two rivers are shown in the accompanying map and diagram, from which it will be seen that the Monte Argento power station, which has been constructed underground, operates under a head of about 52m. The various development schemes on the two rivers have been largely designed and carried out by the Terni Company.

The highest power station of the system is at Cotilia. It is supplied by two connected seasonal reservoirs, with a total capacity of 440 million cubic metres and is equipped with two 30MW turbo-alternator pump sets, so that it is able to regulate the production of all the hydro-electric plants downstream, with almost complete utilisation of the available flow. During flood periods, surplus power is available from power stations in other catchments which have insufficient storage to regulate the floods and this power is used to drive the pumps. Downstream from Cotilia is the Galleto-Papigno plant, with a total installed capacity of 160MW (later to be increased) and an average annual output of 890 million kWh. Lake Piediluco serves as a weekly regulating and compensating reservoir for this power station. Immediately downstream from the Galleto-Papigno tailrace is the Monte Argento intake.

The two seasonal reservoirs above the Cotilia power station—Salto and Turano—are connected by a tunnel 9km in length. There is a pressure tunnel from the Salto reservoir to the Cotilia power station, which is also supplied by a diversion tunnel 19km long from the Velino River, at a higher elevation than the two reservoirs. The capacity of each of the two 30MW pumping sets is almost 20 cubic metres a second (1 cubic metre per second equals 35·32 cusecs) and they are amongst the largest in Europe. The power station



POWER STATIONS ON THE NERA AND VELINO RIVERS

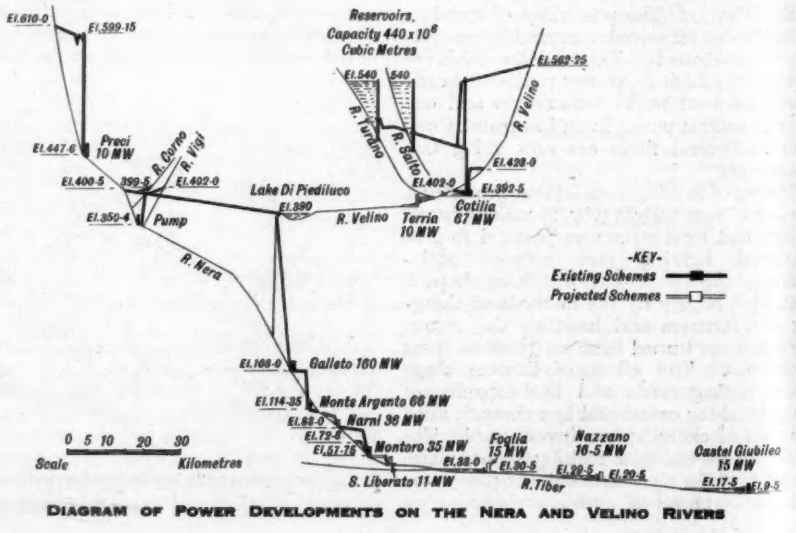
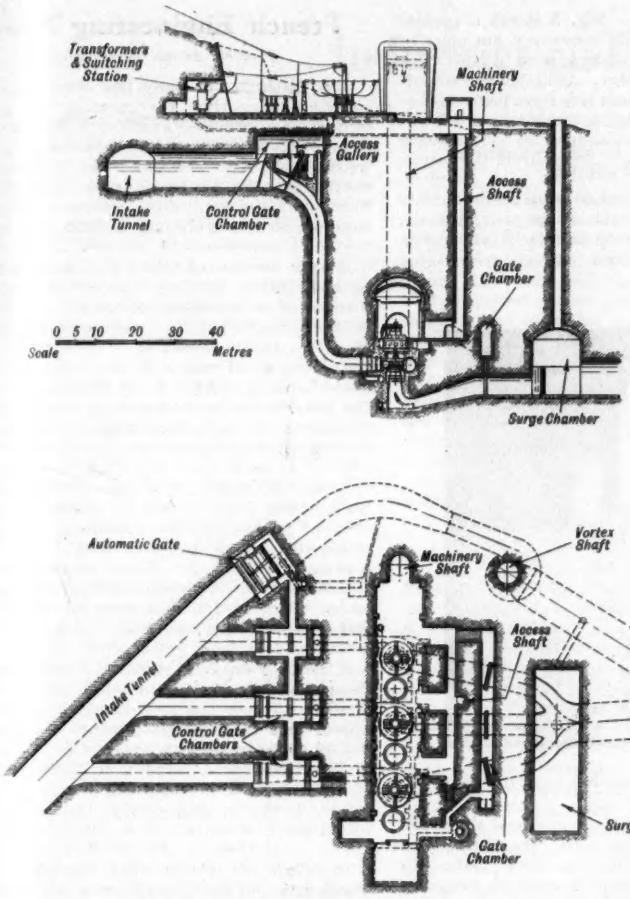


DIAGRAM OF POWER DEVELOPMENTS ON THE NERA AND VELINO RIVERS



PLAN AND SECTION OF MONTE ARGENTO POWER STATION

also contains two minor sets, utilising water diverted from the Canetra and Peschiera.

It is intended to construct another power station downstream from Cotilia near Terria. It will utilise the remaining head down to the natural lake of Piediluco. The waters of the middle course of the River Nera and its tributaries are diverted into Lake Piediluco through a 42km-long tunnel, with a capacity of 26 cubic metres a second. In the Upper Nera region the Terni Company has constructed the Preci plant, which has a capacity of 10MW.

Construction of the Monte Argento power station has increased the total capacity installed in hydro-electric power stations on the Nera and Velino to 346MW, with an average annual output of 1330 million kWh. When the plan for utilising the Nera and Velino is completed, however, these figures will be increased to some 450MW and 1580 million kWh, respectively.

VORTEX SHAFT DURING TEST

The Monte Argento intake works consist of a short canal connecting the Galleto-Papigno tailrace directly to the diversion canal, and a weir on the Nera River. The weir has an automatic taintor gate and a vertical lift gate with spans of 15·8m and 5·9m, respectively. The works replace the intake structures of the old Cervara plant, which gave only partial utilisation of the flow under a lower head.

The diversion aqueduct is 1747m long and is in tunnel for 1377m. The arrangement at the end of the tunnel is shown in the accompanying plan of the power station, where the penstocks leading to the three sets may be noted. The penstocks have an internal diameter of 3·8m and are 65m long. There is an automatic gate installed at the end of the tunnel leading to an inclined tunnel, which terminates at a vortex shaft, which can discharge the full flow in case of a sudden stopping of the station. At the bottom of the vortex shaft there is a tunnel leading to the tailrace. The vortex shaft is shown under test in the accompanying illustration.

The station is equipped with three vertical-shaft Francis turbines, each coupled to an alternator of 27·5MVA capacity (21·9MW) and generating at 214 r.p.m., 50 c/s and 10kV. Entrance to the power station is by a shaft 55m deep in which are the staircase and lift. There is a second shaft 5·5m in diameter for handling machinery. A workshop for transformer assembly has been built above this second shaft so that the overhead crane it contains may also be used for handling the power station machinery. Finally, a third shaft containing the 10kV cables runs from the alternators to the transformers, installed at ground level. There are three transformers, each of 28·8MVA, transforming 10/30/120kV to 150kV.

The tailrace is 1829m long and is completely underground; it discharges into the Nera at an elevation of 114·8m above sea level, slightly upstream from the Garibaldi Bridge in Terni town. A surge chamber connected to the atmosphere by a shaft has been built at the start of the tailrace, where the discharges of the three turbines meet.

The Stud Welding of Light Alloys

By D. C. G. LEES, M.A., A.I.M.*

THE advantages of metallic arc welding in reducing costs and speeding erection are nowadays widely exploited, particularly in the shipyard. Butt and fillet welds have been practised for many years and more recently stud welding has come into its own. This process, in which studs are attached to plates without the need for prior drilling and tapping, was given a great impetus by the requirements of tank production during the last war, although it had been used on a small scale since the early 1920s. In the past few years the increased use of aluminium alloys in ships' superstructures has stimulated work designed to permit aluminium studs to be welded to plates, and the following is an account of the process and the results obtained.

In essence stud welding requires that an arc should be struck between plate and stud, so as to fuse a small amount of each, and the stud is then pressed against the plate. Fig. 1 shows

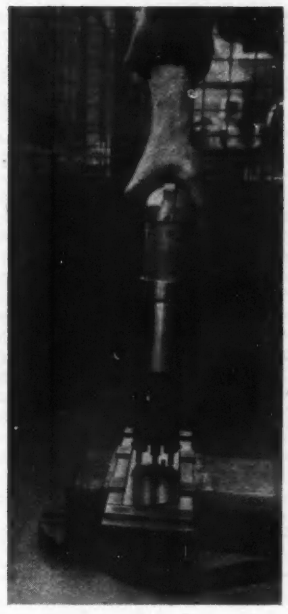


FIG. 1—HAND TOOL FOR STUD WELDING

the hand tool, weighing about 4½ lb, developed by Cyc-Arc, Ltd. It is connected by normal flexible welding cable to a multi-operator d.c. welding set giving about 70V on open circuit. The stud, carrying a ceramic ferrule to contain the expelled molten metal, is lightly held in a spring chuck and the coned or tipped end is placed against the plate. On actuation of the push-button switch in the handle a small current circulates in the welding circuit and the stud is retracted about $\frac{1}{16}$in, thus establishing a pilot arc. The main welding current is next superimposed on the pilot arc and maintained according to the setting of the weld timer. During the period of the main arc some of the plate and stud material is melted and this period (about 0·25 second in duration) is ended by the return of the stud to the plate. Most of the heat is concentrated in the plate,

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since its polarity is positive with respect to the stud.

Cathode ray oscillograms (Fig. 2) show that the welding arc current is of the order of 1000A for a ¼in diameter stud. The arc voltage is 30–31V.

Two forms of stud end have been used on light alloys, one having 120 deg. cone and the other a coned end with a slender projecting tip, which produces improved arc characteristics. In both cases the end is metallised, by a special process, to facilitate arc striking.

As part of its marine activities the Aluminium Development Association has made tests on stud welds made by the Cyc-Arc process, using plate of ¼in, ⅜in and ½in thickness and studs of the same three diameters. Choice of materials was guided by the known suitability for shipbuilding applications of the aluminium alloys containing magnesium in the range up to 5 per cent. Three alloys were therefore tested, namely, N.4, N.5 and N.6 in the British Standard [General Engineering Series (B.S. 1470–1477), the magnesium content being in the range 1·75–2·75, 3·0–4·0 and 4·5–5·5 per cent respectively. All combinations of three alloys were used and approximately 120 welds were made and tested. The studs were about 2in long, all but the first ⅜in of length being threaded (Whitworth).

The plate surfaces were not prepared in any way before welding, although a heavy grease film on the N.6 material was experimentally removed by hand cleaning with solvents. It is not clear that this is essential, although cleanliness in welding is normally an advantage.

Approximately half the welds were tested by hammering the stud parallel to the plate and then twisting until failure occurred. In nearly all cases (fifty-nine out of sixty-two) failure occurred at the root of the first thread, generally after not less than a 90 deg. twist, thus indicating that the welds were sound with very few exceptions. The remainder of the welds were pulled in a tensile testing machine with similar results. In fifty-seven out of the sixty-two welds tested failure occurred at the root of one

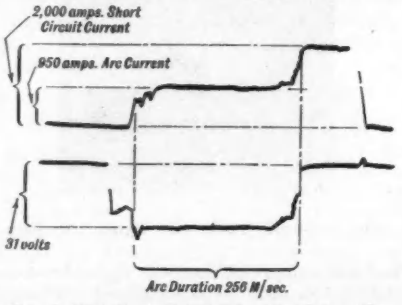


FIG. 2—WELDING CURRENT AND VOLTAGE OSCILLOGRAMS

of the threads and the failing load corresponded to stresses well above the specified ultimate tensile stress calculated on the area at the thread root. Even with a ¼in diameter stud in N.4 alloy, the softest of the three test materials, a pull of about 800 lb was required to break the stud. Failure in the weld occurred in five cases only.

In order to assess the soundness of the welds a few were sectioned, polished and examined at low magnification. As expected from the mechanical test results, a high degree of soundness was revealed and the amount of cast weld metal between stud and plate was very small. The weld metal forced out on the return of the stud and contained by the ceramic ferrule was somewhat unsound, but this has no effect on the strength of the weld. Fig. 3 shows a typical macro-section of a weld between a ⅜in plate in N.4 alloy and a ⅜in diameter stud in N.5. The penetration is satisfactory, although the soundness of the weld prevents this from being visible in the photograph.

STUD WELDING UNDER INDUSTRIAL CONDITIONS

The welds just described were made indoors in close proximity to the motor-generator set, so that conditions were particularly favourable. Experience has also been gained in operating the process out of doors. In one trial about 300 ¼in diameter bifurcated pins were attached to two vertical ¼in thick N.5 alloy plates for special testing purposes and the work was completed satisfactorily in the open air, using current drawn from a 30kW d.c. welding generator, at the rate of about six studs per minute. Subsequently practical use has been made of the process under shipyard conditions, when ¼in diameter studs were welded to ⅜in thick aluminium alloy deck plating during the refitting of a passenger liner. In spite of the work being approximately 100 yards from the generator, no difficulty was experienced and the nuts required to secure the deck planking were tightened up normally.

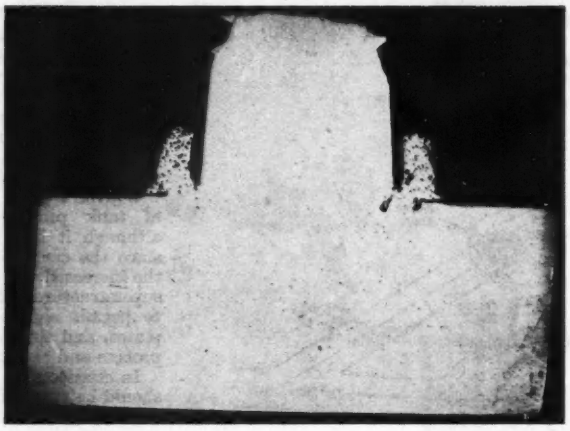


FIG. 3—MACRO-SECTION OF N5 STUD IN ⅜IN N4 ALLOY PLATE

As the utilisation of aluminium alloys expands in general engineering it is anticipated that further applications of stud welding will arise. At present it is found that the stud diameter should not exceed twice the plate thickness, although the ratio could doubtless be increased where the use of a backing plate is practicable. For many purposes this is not possible, and the process is therefore limited to work on plate, extruded sections and castings rather than on light sheet. The amount of metal burnt off the stud corresponds approximately to half the diameter.

The process has been used on steel construction for the attachment of studs used to secure roof decking and for fixing bolts to floor-to-floor windows. Both of these applications appear to be practicable for aluminium. In work on tanks, whether static or in vehicles, stud welding offers the interesting possibility of fixing such components as manhole cover surrounds, which at present are normally fillet welded. The success attained using the process under practical conditions indicates that it is flexible and capable of use on site even when the distance from the source of power is considerable.

AN INDIAN TECHNOLOGY INSTITUTE.—A UNESCO technical assistant expert is going to India to help set up in that country the first large Institute of Technology. The Institute will train young Indians for engineering work in industry and land conservation projects and the Technological Institute situated at Kharagpur, seventy-two miles from Calcutta will be the first of four such institutes to be set up in India.

French Engineering News

(From our French Correspondent)

The Alsthom Company has delivered a new electric locomotive for running on power frequency alternating current. The new locomotive has a 4000 h.p. single-phase motor and weighs 114 tons. Tests will be undertaken on the line between Aix les Bains and La Roche sur Foron. This electrification scheme was referred to in our issue of February 2, 1951.

* * *

A new section of the Paris Metro will be opened during the first quarter of 1952. It consists of an extension of the St. Lazare line to the suburbs of St. Ouen and St. Denis. Work on the new section was started before the outbreak of war and was stopped during the occupation. After being re-started in 1948, the tunnels are now completed and work has started on the surface structures, which should be completed early next year.

* * *

From December 31st the French Mines Service will start a periodic inspection of all thermal power stations producing 1500kg of steam per hour. The aim is to control coal consumption and cut down waste. A new organisation to carry out this inspection and to advise users on the best ways of saving coal and avoiding waste, has been set up.

* * *

A meeting was held recently in the Gabon to discuss oil prospecting in that area. Work carried out over the past few months, it was stated, had produced satisfactory results, and the oil found appeared to be of good quality. It was therefore decided that drilling should continue for another four months in the area, by which time a clear picture of the situation would be possible.

* * *

Electricité de France has announced the inauguration of the hydro-electric power station at Egleros, in the south-east. The construction, which was expected to take four years, was started in 1946, but many difficulties were encountered during the course of the work. The annual power production will be about 132 million kWh.

* * *

The Halles Centrales in Paris are to be rebuilt. The aim is to provide modern facilities for vegetable and other wholesalers. Work will start shortly on the new structures, which will differ entirely from the old existing ones, which are virtually vast sheds. Modern machinery will be installed and the whole market will be brought up to date. The rebuilding will have to be carried out while the usual activities of the market continue, thus involving some interesting engineering work.

* * *

The construction of a large aerial railway near Chamonix is again being considered, 230 million francs having recently been made available under the Monnet plan. The departure point would be situated in the centre of Chamonix, where a line of conventional construction would lead to an intermediate station at an altitude of 2300m. From there a second line would lead to the summit of the Aiguille du Midi, at an altitude of 3842m. A distance of 2489m separates the two points, with no possibility of building an intermediate supporting pylon. A single-span cable, 57mm in diameter and 2892m long, will therefore carry the carriage. The latter, weighing 1 ton, would cover the distance in 4·5 minutes, and would carry forty-six passengers, thus providing a maximum traffic of 500 passengers an hour. The carrying capacity of the car would be as great as 270,000 kg. The most interesting part of this project will be the higher station. Since bad weather and particularly lightning are to be feared at this altitude, a refuge capable of holding 600 persons will be provided, excavated in the summit and reached by a 25m bridge over a ravine. A number of passages will be arranged round the station, giving access to a panoramic bridge circling the mountain. Other bridges and tunnels will lead to the Midi-Plan, from which skiers can reach Chamonix.

Industrial and Labour Notes

The Fuel and Power Situation

The fuel and power situation was discussed by the Trades Union Congress on Thursday of last week, during its annual assembly in Blackpool. The matter was introduced, on behalf of the general council, by Mr. T. Williamson, who said that the power position was more critical than at any time since 1947, and unless stern measures were taken there was every indication of serious industrial shut-downs during the coming winter, even with normal weather. Both sides of industry, Mr. Williamson continued, had considered the matter and could see no adequate means of avoiding load shedding that did not involve some adjustment of hours of work. Those adjustments, he thought, might involve double shifts and night work between November and March and he appealed to unions to co-operate with the Electricity Boards.

Later in the debate, Mr. W. E. Jones, of the National Union of Mineworkers, said that, although in the first thirty-five weeks of this year, 4,500,000 tons more coal had been raised than in the corresponding period last year, consumption had increased by 5,500,000 tons, and output from opencast workings had declined by 1,250,000 tons. Though manpower in the coal industry had risen by 15,000 between November of last year and April of this year, after April it had begun to fall at the rate of 15,000 a year and, Mr. Jones added, to get through the coming winter it would be necessary to import coal. Nevertheless, he said, the nationalised coal industry would remember its responsibility to the trade union movement and to the country and would make its contribution to the economic well-being of Britain. Mr. Arthur Horner, secretary of the National Union of Mineworkers, also contributed to the discussion by pointing out that there could be a fuel crisis this winter, which might be more severe than that of the winter of 1946–47. He said that he could not see how, with less than 700,000 men in the coal-mining industry, and with a regular fall of about 400 a week, it would be possible to get the coal required to maintain full employment and bolster up the economy of the country.

A day or two before the T.U.C. debate on fuel and power, the Industrial Coal Consumers' Council discussed the fuel outlook for next winter. A statement issued after its meeting said that, having heard reports from different authorities about the widening gap between production and consumption, the Council decided to recommend the Ministry of Fuel and Power to draw up a realistic winter programme of individual coal and coke allocations at the earliest possible moment. The Council also warned industrialists to plan their operations on the assumption that there would be a serious shortage of fuel, especially of large coal, carbonisation coal and coke.

The T.U.C. Discussion on Wages

On Thursday afternoon of last week, the Trades Union Congress dealt with resolutions concerning the cost of living, wages, prices and profits. The principal resolution on wages was submitted by the Electrical Trades Union. It claimed that, despite wage increases during the past twelve months, there had been a steady deterioration in the living standards of workers, owing to the steep rise in the cost of living. The resolution declared, therefore, that further wage increases were essential for all sections of the workers and that "the standards of living of the people must be improved at the expense of profits."

The resolution was not carried. Speaking against it, Mr. W. L. Heywood, of the T.U.C. General Council, said that the council was not against applications for wage increases. It had to be recognised that they were justified and that they would continue to be presented by affiliated unions. But he warned the Congress against linking wages with profits, arguing that an increase of wages, when profits increased, involved the contrary when profits declined.

In the course of an address to the Congress earlier last week, the Chancellor of the Exchequer, Mr. Hugh Gaitskell, stressed the need for moderation in wage claims, particularly during the next few months. He admitted that increased prices now working their way through the economic system were bound to put up the cost of living index two or three more points by the end of the year, but raw material prices had begun to fall and, externally, things might then settle down. But, the Chancellor said, the cost of living here would go on rising in 1952, even with stable world prices, if our own costs continued to be pushed up through further substantial rises in wages and salaries.

Europe's Coal Requirements

The coal committee of the United Nations Economic Commission for Europe has recently concluded a session at Geneva. A principal item in its discussions was the problems associated with the distribution of 8,200,000 tons of coal and 2,500,000 tons of coke during the final quarter of this year. A distribution programme was examined in detail and the committee decided that, in the hope of reaching a general agreement, an urgent appeal should be addressed to the exporting countries for an increase in the quantities which they can make available. According to the committee, the additional tonnages needed to give "austerity satisfaction" to all countries were estimated at 1 per cent of coal requirements and between 4 and 5 per cent of coke requirements. The committee also studied forecasts of Europe's solid fuel requirements and availabilities in 1952. The figures considered were, of course, provisional, but they indicated that Europe faces next year a possible deficit of from 10,000,000 to 12,000,000 tons of coal and 5,000,000 tons of coke.

Trade Disputes

According to the *Ministry of Labour Gazette*, there were 101 stoppages of work through industrial disputes, reported as beginning in July, and a further nine stoppages, which had started earlier, still in progress during the month. In those 110 stoppages, 16,900 workers were involved directly and indirectly in July, the aggregate number of working days lost being estimated at 42,000. In June, 305,000 working days were lost on account of stoppages through disputes, and in July last year the ninety-one stoppages which occurred caused an aggregate loss of 250,000 working days. In the first seven completed months of this year, there were 1007 stoppages through disputes reported to the Ministry of Labour. They involved 254,800 workpeople and resulted in an aggregate loss of 1,263,000 working days.

Ministry of Labour's Annual Report

The annual report of the Ministry of Labour and National Service for the year 1950 has been published this week (H.M. Stationery Office, price 6s.). It records the principal activities of the Ministry's organisation and covers, as usual, a wide range of subjects, including the manpower situation, the employment services, training schemes, the resettlement of disabled persons and of ex-regular members of the Forces, the welfare of workpeople, industrial relations and international labour relations.

In the chapters dealing with manpower, the report shows that the total working population of this country at the end of 1950 was 23,180,000, which indicated an increase during the year of 218,000 (91,000 men and 127,000 women). At the end of November last, the working population was the highest ever attained in peacetime and throughout the year the tendency for more women to remain in or return to employment continued. The report directs attention to the fact, however, that the flow of young people to employment was still affected by the low birth-rate of the 1930s. The total number of people in civil employment at the end of last year was 22,100,000, which represented about 95 per cent of the working population. During the year the number in civil employment increased by 234,000, the increase in the manufacturing industries amounting to 214,000. The report also notes that last year a further 4770 foreign workers were brought to this country under the Ministry's official schemes, and that about 35,000 permits were granted to employers for the admission of individual foreigners to enter employment here. Unemployment last year remained at a low level, the number of registered unemployed never exceeding 1·8 per cent of total employees.

The section of the report dealing with industrial relations records that about 300 disputes were settled by agreement between the parties at, or following, meetings arranged by the Ministry's conciliation officers. The Industrial Court issued forty-three awards last year and under the Conditions of Employment and National Arbitration Orders there were 425 cases reported in 1950. In addition, 110 cases were still outstanding at the beginning of the year. Of those 535 cases, 239 were referred to the National Arbitration Tribunal, ten to machinery established under the Industrial Courts Act, and 162 were settled by other means, leaving 124 cases outstanding at the end of the year.

Index of Industrial Production

The Central Statistical Office of the Treasury has estimated provisionally that the index number of industrial production (1946=100) for June, 1951, was 149, compared with a revised figure of 143 for May. Figures for the corresponding months of last year were 143 for June and 141 for May. For the manufacturing industries alone, the June, 1951, index has been estimated at 157, compared with 149 in May and 150 in June, 1950. The Treasury says that information so far received for July, 1951, indicates that the index for all industries will be 138 or 139. July, of course, is affected by annual holidays. With the figures for June, the Treasury suggests that industrial production in the United Kingdom during the first half of this year was about 4½ per cent higher than in the corresponding period of 1950.

The Taxation of Profits and Income

The Federation of British Industries has published the first memorandum which it has submitted to the Royal Commission on the Taxation of Profits and Income. The purpose of the Commission, it may be recalled, is to examine whether the present system of taxation is satisfactory, or if it could be improved in relation to such matters as incentives, risk bearing and the control of inflationary or deflationary tendencies.

The F.B.I. memorandum makes observations on the taxation of salaries and wages, profits of businesses and dividends and other sources of income. Among other matters, it points out that it is not possible to reward good work in management in any way which does not result in the greater part of the reward reaching the State in taxation. The F.B.I. view is that, short of a substantial reduction in the level of taxation as a whole, the removal of the worst effects of income tax upon the incentives to work can be achieved only by a fundamental change in the tax structure itself, which reduces the gap between the average rate of tax upon the wage or salary and the marginal rate of tax upon the top slice of that wage or salary.

Notes and Memoranda

Rail and Road

RAILWAY TRAINING SCHOOL AT CREWE.—The Railway Executive has stated that a school for training apprentices is to be built at Crewe, Cheshire. It will be adjacent to the locomotive works and will become the "nursery" supplying the locomotive and other technical departments with some 270 apprentices each year. The school will accommodate three times as many apprentices as the existing school at Derby, which has proved very successful. The building will have two storeys. On the ground floor there will be a large workshop around which will be built accommodation for the principal, lecturers, and administration. Above, on the first floor, will be classrooms, drawing-offices and a library, and an assembly hall will be constructed adjacent to the school. Boys will join the school at the age of fifteen, and during the year they spend there they will have preliminary practical and theoretical instruction to fit them for the class of work in which they will specialise during the course of their apprenticeship. At fifteen years of age the apprentices will receive 29s. a week, rising to 71s. a week at twenty years of age. The site for the new school has already been cleared and building is expected to begin by the end of this year.

Air and Water

SUEZ CANAL SHIPPING TRAFFIC.—During the first six months of this year 39,117,000 tons net passed through the canal, 18,931,000 tons in the first quarter and 20,186,000 in the second, representing an increase of 194,000 tons over the corresponding period of last year. The total included 13,607,000 tons of British shipping, the figure for the same period in 1950 being 12,366,000 tons.

FIRST GAS TURBINE ENGINED TANKER.—The 12,000-ton deadweight tanker "Auris," owned by the Anglo-Saxon Petroleum Company, Ltd., is at present at the Hebburn shipyard of R. and W. Hawthorn, Leslie and Co., Ltd., for the purpose of installing a gas turbine alternator unit. The unit was built by the British Thomson-Houston Company, Ltd., of Rugby, and takes the place of one of the four diesel-electric alternator sets which originally powered the ship. It is expected that the ship will be ready for trial next month, and then the gas turbine alternator set will commence an experimental period under seagoing conditions in order to assess its capabilities and to gain experience with this form of prime mover.

SAFETY OF LIFE AT SEA.—The Ministry of Transport states that the U.S.S.R. has recently deposited with the Foreign Office its acceptance of the revised collision regulations agreed on at the 1948 Conference on Safety of Life at Sea. Acceptances of the International Regulations for Preventing Collisions at Sea, 1948, have now been deposited by twenty-nine countries, with a total gross tonnage of the merchant fleets of these countries amounting to over 40,000,000 tons. In accordance with the decision reached at the International Conference on Safety of Life at Sea, 1948, the date on and after which the regulations must be applied by the Governments which have accepted them will be fixed by the Government of the United Kingdom when substantial unanimity has been reached as to acceptance. It is hoped that this stage will be reached shortly. At least one year's notice of this date will be given to all the Governments concerned.

Miscellanea

A CEMENT WORKS IN DERBYSHIRE.—The Minister of Local Government and Planning has given permission for the building of a cement factory and the working of limestone and clay at Dove Holes, Derbyshire. This permission has been given to the Ketton Portland Cement Company, which proposes to build a one-kiln works to produce 100,000 tons of cement a year.

SHOREHAM CEMENT WORKS.—It has been pointed out that in our description of the new cement works at Shoreham in our issue of July 27th last, page 122, the equipment described under the headings of "Chalk and Clay Quarries" and "Packing Plant," was designed and manufactured by Richard Sutcliffe, Ltd., Universal Works, Horbury, Wakefield.

CITY AND GUILDS OF LONDON INSTITUTE.—The City and Guilds of London Institute for the Advancement of Technical Education announces the appointment of Mr. J. W. Voelcker, A.C.G.I., B.Sc., A.M.I.E.E., as Secretary of the Institute, to succeed Mr. G. C. Stephenson, A.C.A., who has now retired. Mr. Stephenson, who will continue to help and advise in the work of the Institute, has been its secretary since 1924. Mr. Voelcker was educated at Rugby, where he was amongst the first members of the Science Side. After serving in the first world war with the Royal Engineers, he gained a Governors' scholarship to the City and Guilds College, where he studied electrical engineering in 1920–22. In the latter year he went to the United States and, after post-graduate study leading to a Master's Degree and some teaching experience at the Massachusetts Institute of Technology, he returned in 1925 to join the English Electric Company, Ltd., with which he remained until the present appointment.

TELEVISION EQUIPMENT FOR LIME GROVE STUDIOS.—Part of the television equipment for the B.B.C.'s new Lime Grove studios has been ordered from Marconi's Wireless Telegraph Company, Ltd., who will supply nearly £50,000 worth of apparatus, including six complete Marconi "Image Orthicon" camera chains, nine 10in picture monitors, one supervisory desk, one 16in picture monitor, one complete set of intercommunication equipment, vision mixing, relaying and amplifying installations, waveform generators and test equipment, and six "Monoscope" cameras and camera channels.

COURSE IN PUBLIC HEALTH ENGINEERING.—A course in public health engineering at King's College, Newcastle upon Tyne (University of Durham), was instituted last October and has now completed its first year. The course is intended for graduates in civil engineering who wish to enter those branches of the profession concerned with water supply and treatment, sewage treatment, district heating and the colonial service. During the next session a series of twenty weekly lectures, by Dr. A. T. Palin, on the chemistry of water treatment, has been arranged; this series is open to anyone interested on payment of a fee of one guinea.

DEFINITIONS AND FORMULÆ FOR STUDENTS: PRACTICAL MATHEMATICS.—Those students who feel the need for a booklet containing a collection of rules and formulæ in practical mathematics will be interested in the appearance of the third edition of "Definition and Formulæ for Students: Practical Mathematics," by L. Toft, published by Sir Isaac Pitman and Sons, Ltd., Parker Street, Kingsway, London, W.C.2. In addition to sections on algebra, trigonometry and mensuration, differential and integral calculus, graphs and co-ordinate geometry, and differential equations, the booklet includes a section on statistics and quality control.

METALLURGISTS TO VISIT AMERICA.—It is announced that the Economic Co-operation Administration has set aside more than half-a-million dollars to enable eleven groups of leading metallurgists from Marshall Plan countries to attend the World Metallurgical Congress in Detroit, in October next. Of the 500 metallurgists who are expected to participate in the meeting, more than half are under direct sponsorship of E.C.A. and will receive travel and subsistence allowances within the United States as part of the Administration's technical assistance programme. Travelling teams of visitors will inspect the American metal industry in a series of tours preceding and following the congress.

"RYTHMATIC" RIPPLE CONTROL: INCREASE IN SIGNAL AVAILABILITY BY "CODING."—A booklet (Engineering Bulletin No. 2225) has been published by the Automatic Telephone and Electric Company, Ltd., Liverpool, 7, giving details of a "coding" system whereby the availability of the system can be increased without duplication of apparatus. This coding system requires the transmission of two signals, instead of only one, for each remote switching operation, and it uses relays having two selective units, instead of only one at each switching point. Accordingly, the signal availability is increased as the square of the number of basic signals coded; for example, four basic signals give sixteen coded signals.

PRESSURE GAUGE MANUFACTURERS' ASSOCIATION.—For some years past several of the leading British manufacturers of pressure gauges have been members of the B.S.I. committee drafting the first British Standard for pressure gauges, and during the discussions is has become increasingly evident that the industry could reap considerable advantage if means were established to enable manufacturers to contact one another readily. A meeting has therefore been held, which resulted in the formation of the British Pressure Gauge Manufacturers' Association. The Association will not in any way concern itself with the control or maintenance of prices or any other restrictive practices. Dixon, Hopkinson and Co., of 15a, Steelhouse Lane, Birmingham, 4 (telephone, Central 7711), have been appointed secretaries of the Association.

TRAINING COURSES FOR INSTRUMENT MECHANICS AND ENGINEERS.—We learn that George Kent, Ltd., of Luton, has begun a series of integrated training courses for instrument mechanics and engineers from customers. The courses last for four or five weeks, depending on the requirements of the trainees, during which period whole-time instruction is given on the theory, operation and maintenance of a wide range of Kent instruments and control apparatus. A workshop and lecture room have been specially provided and equipped for these training courses at the Luton works. Inquiries should be addressed to the Training Officer, George Kent, Ltd., Luton.

THE B.E.A. AND CONSULTING ENGINEERS.—The British Electricity Authority desires it to be known that, while its own staff is carrying out the design work for the majority of new power stations, a proportion of these projects is being entrusted to consulting engineers as a matter of policy. In coming to the decision to supplement the work of its own staff in this way, the Authority has had in mind the widening of experience resulting from the utilisation of the existing organisations of consulting engineers and the national importance of the work which consulting engineers do abroad. Long-term agreements have been entered into with Messrs. Merz and McLellan, Kennedy and Donkin, and Ewbank and Partners, covering the complete engineering and supervision of a number of stations in the Authority's future programme. Similar agreements for certain specific stations have also been entered into with Messrs. Preece, Cardew and Rider, and Messrs. Strain and Robertson. On the civil engineering and building side, the Authority is employing specialist consultants and architects on a great proportion of new stations.

Personal and Business

THE KING has been graciously pleased to approve the appointment of General Sir Edwin L. Morris, K.C.B., O.B.E., M.C., as Chief Royal Engineer, in succession to General Sir Guy C. Williams, K.C.B., C.M.G., D.S.O., whose tenure expired on September 10th.

MR. PHILIP COOK and Mr. Frank Ridley have been appointed directors of Daralum Castings, Ltd., Darlington. Mr. Cook also becomes general manager, and Mr. Ridley, secretary, of the company and its associate, John Vickers and Sons, Ltd.

METROPOLITAN-VICKERS ELECTRICAL COMPANY, Ltd., states that Mr. G. B. Hayward, A.M.I.E.E., has been appointed manager of the Plymouth suboffice, in succession to Mr. W. S. Livsey, who has transferred to Metropolitan-Vickers Export Company, Ltd.

MR. J. A. CORNISH-BOWDEN, M.I.Mar.E., has been appointed sales manager of Berger Equipment, Ltd., Moor Lane, Staines, Middlesex, in succession to Mr. W. Graham. Mr. D. E. Davis, A.M.I.Mech.E., has been appointed chief development engineer.

THE MINISTER OF FUEL AND POWER has appointed Mr. W. J. Drummond, deputy chairman of the National Coal Board, as a member of the Industrial Coal Consumers' Council and of the Domestic Coal Consumers' Council in place of the late Sir Arthur Street, formerly deputy chairman of the Board.

THE BRITISH ELECTRICITY AUTHORITY announces the appointment of Mr. P. W. Cash, B.Sc. (Eng.), A.C.G.I., M.I.Mech.E., as technical executive assistant to Sir John Hacking, M.I.E.E., deputy chairman (operations) of the Authority. He succeeds Mr. G. R. Peterson, M.I.E.E., who has been appointed generation operation engineer in the chief engineer's department.

BESTWOOD, FRASER AND WEIR, Ltd., is an association of three companies at present operating in Great Britain, South Africa and the U.S.A., and has been formed to provide consulting and mining engineering services in those three countries and elsewhere. The first directors are Mr. R. C. Lancaster (chairman), Mr. Hugh Fraser, Mr. Paul Weir and Sir Eric Young. Mr. Lancaster is joint managing director of the Bestwood Company, Ltd., Nottingham, which formerly controlled and operated the B.A. Collieries' undertakings in Nottinghamshire. He is also a vice-president of the Paul Weir Company, Inc. Mr. Fraser is managing director of H. H. Fraser and Associates (Pty.), Ltd., industrial consultants, Johannesburg. Mr. Paul Weir is president of the Paul Weir Company, Inc., consulting mining engineers, of Chicago, and Sir Eric Young was for many years managing director of the Bolsover Colliery Company, Ltd., and until recently a member of the National Coal Board. The registered office of the new company is at 22, Ryder Street, St. James's, London, S.W.1.

British Patent Specifications

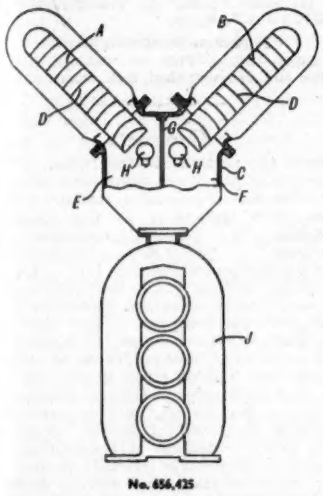
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery Lane, W.C.2, 2s. each.

RAILWAY ENGINEERING

656,425. January 6, 1949.—Illuminated Signal Devices for Railways, The Westinghouse Brake and Signal Company, Ltd., and Leslie Hurst Peter, both of 82, York Way, King's Cross, London, N.1.

This invention relates to illuminated signal devices for railways for giving an indication of the route set at a track divergence. Referring to the drawing it will be seen that the indicator is arranged to give a route indication for one or other of two divergent routes at a track divergence, and comprises two indicator arms *A* and *B*, each consisting of a relatively elongated plate or bar of the transparent plastic material known as methacrylate or methylacrylate. The lower ends of the arms, the axes of which are inclined to one another at an angle of approximately 90 deg., are mounted on a box or casing *C*. The rear surface of each of the arms is



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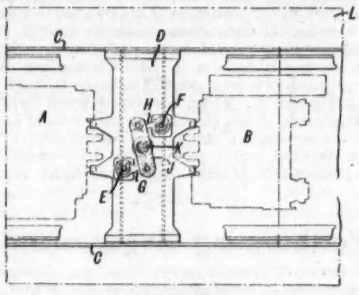
provided with a series of relatively closely spaced lines or bands *D* etched or otherwise formed on the plastic. The interior of the box *C* is divided into two compartments *E* and *F*, by an opaque partition *G*, each compartment containing an incandescent electric lamp *H* so arranged that the light rays emitted by the lamp enter the lower edge of the plastic arm, and by internal reflection illuminate the spaced lines or bands *D*, which are curved so as to be concentric with the filament of the corresponding lamp. The box or casing *C* may be mounted as shown upon the casing *J* of a three-aspect colour-light signal. The circuit of one or other of the lamps is supplied with current automatically in accordance with the route which has been set.—*August* 22, 1951.

656,298. September 9, 1948, and April 1, 1949.—Railway Vehicles, Metropolitan-Vickers Electrical Company, Ltd., of St. Paul's Corner, 1–3, St. Paul's Churchyard, London, E.C.4 (*inventor, Nevin Thorneley*).

This invention relates to the connection of a bogie with the superstructure of a railway vehicle, such as a locomotive or motor coach. As shown in the drawing, the bogie is provided with two axles and is motorised by the axle-hung electric motors *A* and *B*. The side frames *C* are connected together by suitable cross members including a central cross member *D*, which is of welded box-like construction. Two short vertical stub bearing pivots *E* and *F* are mounted on the upper face of the cross member *D* by means of plates; links *G* and *H* are pivoted, preferably by means of flexible bushes on *E* and *F* respectively. The other ends of these links are pivotally secured beween the respective forked ends of an equalising link *J* which is inclined to the transverse axis of the bogie and which is itself pivotally mounted on a king pin *K* carried on an underframe of the vehicle superstructure *L*. It will be appreciated that the arrangement occupies a comparatively small space in the longitudinal direction and may easily be arranged as shown between the two axles of the bogie on a single cross member thereof. Moreover, the bending moments on the pivots will be relatively low. The arrangement permits a limited relative transverse movement of bogie and superstructure, and is particularly



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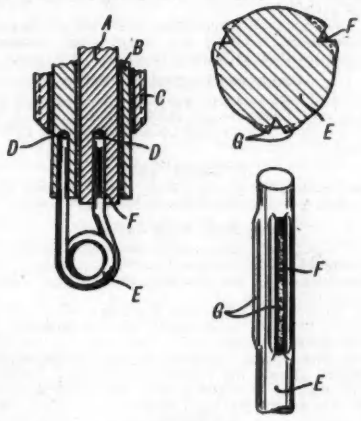
suitable for use where the weight of the superstructure is carried on the bogie by means of swing links in the manner described in Specification No. 16,861 of 1947.—*August* 22, 1951.

ELECTRICAL ENGINEERING

656,339. January 4, 1949.—Incandescent Plugs, Robert Bosch, G.m.b.H., of 4, Breitscheidstrasse, (14a) Stuttgart-W., Germany.

The chief object of the invention is to provide an incandescent plug in which the incandescent wire can easily be exchanged or replaced. The incandescent plug illustrated in the drawings is formed with an inner electrode *A*, an outer tubular electrode *B*, and an outer casing or cap *C*. The electrodes are insulated from one another and from the cap, and are formed with bores *D* in which the ends of an incandescent wire *E* are received, the incan-



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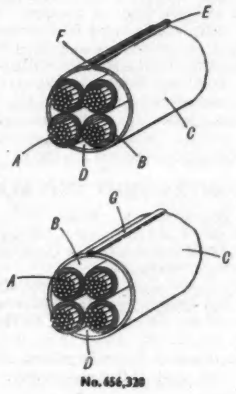
descent wire being formed with a helically wound coil. The ends of the incandescent wire *E* are formed with longitudinal notches or recesses *F* which give rise to longitudinal projections *G* on each side. When the ends of the incandescent wire are forced into the bores *D*, the projections *C* are deformed and engage with a relatively high surface pressure on the faces of the bores so as to provide an adequate surface contact to enable a sufficiently heavy current to flow whilst avoiding the necessity for precision fitting of the wires into the bores. Should the incandescent wire become damaged it can readily be withdrawn from the electrodes and a fresh wire can be forced into position.—*August* 22, 1951.

656,320. January 3, 1949.—Oil or Gas-Filled Electric Cables, Pirelli-General Cable Works, Ltd., of 343–5, Euston Road, London, N.W.1; and Adrian Neville Arman, of that company.

The invention relates to electric cables of the type comprising a fluid-tight sheath surrounding the core or cores and containing oil or gas under pressure. It provides a sheath consisting of a strip of metal of tensile strength materially greater than that of lead, bent to plain cylindrical form and welded along a seam parallel to the axis of the sheath. Referring to the upper view in the drawing, the cable comprises four cores, each constituted by a series of stranded wires *A* surrounded by insulation *B*. The cores are surrounded by a cylindrical sheath *C* of steel, aluminium or other metal possessing a tensile strength materially greater than that of lead, the spaces *D* enclosed within the sheath and lying between the cores being filled with oil or gas, and also, in some cases, partly filled with paper or other packing. The sheath *C* is constituted by a strip bent to plain cylindrical form and, as indicated, having its edges turned outwards to form longitudinal flanges *E* and *F*, which bear the one on the other. These flanges are then welded together, the process described in Specification No. 637,826 being found particularly suitable for this purpose. The lower view shows the sheath *C* again formed from a strip bent to cylindrical form, the strip being of such a width that when so bent a narrow space is left between the edges, this space being filled with brazing material *G*. This construction has the



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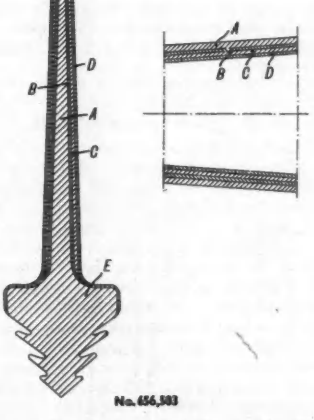
advantage over that previously described, in that the projecting rib formed by the welded flanges *E* and *F* does not appear, the brazing material *G* being flush with or extending only slightly beyond the general cylindrical contour of the sheath. If desired, any protruding brazing material can be removed so that the sheath shows no deviation externally from the true cylindrical form.—*August* 22, 1951.

GAS TURBINES

656,503. October 26, 1948.—Members for Use in Heat Engines, Societe Nationale d'Etude et de Construction de Moteurs d'Aviation, of 150, Boulevard Haussmann, Paris, France. (*Inventor, Yves le Sech*).

The drawings show a cross section through a blade adapted to be mounted on a wheel of a gas turbine and axial cross sections of a part of a combustion chamber. The blade includes a core *A* of highly refractory alloy with a high creep resistance, such as austenitic steel containing nickel and chromium. This core is covered by a metal coat *B* of nickel deposited electrolytically after an appropriate surface treatment of the core such as pickling. The layer *B* is then covered with a layer *C* of a zirconium oxide base enamel incorporating further refractory oxides such as molybdenum oxide, vanadium oxide, tungsten oxide, and the like. This layer is formed by atomisation. It is baked initially, then superficially glazed with an enamel of the same composition with the omission, however, of the refractory oxides. The adherence



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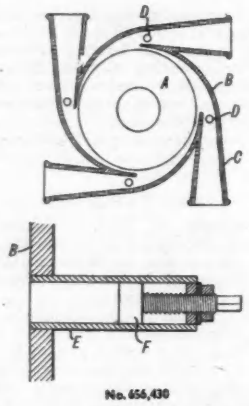
of the layer *C* to the nickel forming the layer *B* may be improved by depositing at the very beginning of the atomisation a light spray of fritted enamel, crushed without any refractory oxide in it, but with the incorporation of nickel and bismuth ions. Lastly the layer *C* is covered by a layer *D* of chromium deposited electrolytically after priming the metal into the surface of the layer *C*. This priming may be effected by the cementation of the layer by means of a liquid suspension of a chromium salt that is easily decomposable by heat, the suspension being spread with a brush over the enamel and

then brought to a temperature that is lower than the softening point of the glazing layer of the enamel. It will be noticed that in proximity to the tail end *E* of the blade the metal layer *D* engages directly the metal layer *B* covering the core *A*, so as to form a sheath enclosing the enamel layer and also a closed heat conductive circuit which is of advantage for withdrawing towards the mass of the rotor the heat accumulated in the metal layers. The combustion chamber includes a core or support of tubular shape *A* that is made of a non-refractory metal such as soft iron or copper. The core is coated internally with a layer *B* of zirconium enamel of low refractory properties and then with a layer *C* of a refractory metal such as nickel, cobalt and chromium, and lastly with a layer *D* of highly refractory enamel that may also be a zirconium enamel, laden, however, with a larger amount of refractory oxides. A similar construction is used for the hot gas pipe.—*August* 22, 1951.

AIR COMPRESSORS AND BLOWERS

656,430. January 11, 1949.—Reducing the Noise of Radial-Flow Compressors and Blowers, Maschinenfabrik Oerlikon, Oerlikon, near Zürich, Switzerland.

This invention consists in providing at the diffuser of the compressor or blower at least one acoustic resonator which is tuned to the frequency of the rotor vanes. As shown in the accompanying drawings, *A* denotes the vane wheel, *B* the casing, *C* the diffusers, and *D* the resonators. A suitable



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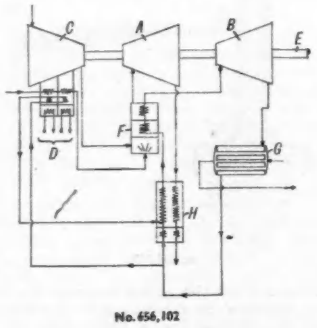
resonator consists of a tube *E* closed at one end, the length of this tube being dependent upon the rotor vane frequency to be suppressed. The length can also be made variable. For this purpose the tube is closed by a piston *F*. By rotating the spindle, the piston is displaced so that the resonator can be tuned. It is advisable to arrange the resonator in the vicinity of the tongue of the diffuser entry, but the resonator may also be formed by a recess provided in the wall of the casing of the blower.—*August* 22, 1951.

GAS AND STEAM TURBINES

656,102. August 24, 1948.—Combined Gas and Steam Turbine Systems, Friedrich Kluge, D.Ing., of 273, St. Vincent Street, Ladywood, Birmingham, 16.

This invention is intended to enable the waste heat generated in combined gas and steam turbine systems to be utilised for improving the heat



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economy. Referring to the drawing, *A* is a gas turbine, *B* is a steam turbine, and *C* is a compressor for the combustion air, having three stages with a pair of interstage coolers *D*. The units are in alignment along the common shaft *E* on which their rotors are mounted for operation at the same speed. The combustion chamber *F* is arranged directly to serve the gas turbine *A* with products of combustion from the combustion of liquid or gaseous fuel received at the burner and air received from the compressor *C*. To prevent overheating at the combustion chamber unit and to supply steam to the turbine, a boiler element, which may include a superheater portion, is associated with other parts of the unit *F*. A condenser *G* is arranged to receive the exhaust of the steam turbine, and a heat exchanger *H* is provided, through which exhaust from the gas turbine *A* is led. Condensate from the condenser *G* is returned to the boiler through the heat exchanger *H*. Thus, heat is recovered from the exhaust gases of the gas turbine and utilised in the condensate part of the circuit which serves the steam turbine, more particularly to preheat the liquid ahead of its boiler.—*August* 15, 1951.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

Association of Supervising Electrical Engineers

To-day, Sept. 14th.—Bristol Branch: Grand Hotel, Bristol, "The Development of the Clyde Passenger Steamer," A. S. Miller, 7.30 p.m.——Crewe Branch: Crewe Arms Hotel, Crewe, "Limitations of Science," J. Levitt, 7.30 p.m.——Nottingham Branch: Old Angel Inn, Storey Street, Nottingham, "Power Cable Design," F. V. Howitt, 7.30 p.m.

Tues., Sept. 18th.—Bournemouth and Portsmouth Branches: Polygon Hotel, Southampton, "Electrical Protective Gear in Factories," G. L. Leighton, 7.30 p.m.

Wed., Sept. 19th.—Manchester Branch: Engineers' Club, Albert Square, Manchester, "Application and Development of Resistance Welding," R. Bushell, 7.30 p.m.

Thurs., Sept. 20th.—Kent Branch: County Hotel, Canterbury, "Electric Telemetering Systems," F. C. Hill, 8 p.m.

Sat., Sept. 22nd.—Oxford Branch: Visit to Clarendon Laboratories, Oxford, and lecture on "Electrical Apparatus Used in Nuclear Research," 2.30 p.m.

Cement and Concrete Association

Mon. and Tues., Sept. 24th and 25th.—Institution of Civil Engineers, Great George Street, Westminster, S.W.1, Symposium, "Prestressed Concrete Statically Indeterminate Structures."

Engineers' Guild

Thurs., Sept. 27th.—Caxton Hall, Caxton Street, Westminster, S.W.1, Annual General Meeting, 6 p.m.

Incorporated Plant Engineers

Tues., Sept. 18th.—Edinburgh Branch: Chamber of Commerce, 25, Charlotte Square, Edinburgh, "The Construction of the Modern Oil Refinery," W. M. Greenhorn, 7 p.m.

Wed., Sept. 19th.—Western Branch: Grand Hotel, Bristol, "Steam Peaks and Thermal Storage," Dr. E. G. Ritchie, 7.15 p.m.

Thurs., Sept. 20th.—Liverpool and N. Wales Branch: Radiant House, Bold Street, Liverpool, "Industrial Lighting," by an engineer from the British Thomson-Houston Company, Ltd., 7.15 p.m.

Institute of Marine Engineers

Tues., Oct. 2nd.—85, Minories, London, E.C.3, Presidential Address, S. F. Dorey, F.R.S., 5.30 p.m.

Institute of Navigation

Fri., Oct. 19th.—Royal Geographical Society, 1, Kensington Gore, S.W.7, Presidential Address, "Navigation and the Shipping Industry," Sir Robert Watson-Watt, 3 p.m.

Institute of Petroleum

Wed., Sept. 19th.—Manson House, 26, Portland Place, London, W.1, "Our Unproduced Reserves: What are They?" Morris Muskat, 5.30 p.m.

Institute of Road Transport Engineers

Tues., Sept. 18th.—Midlands Centre: Crown Inn, Birmingham, "The Servicing of Brakes," J. Kinchin, 7.30 p.m.

Wed., Sept. 19th.—N.W. Centre: Victoria Hotel, Wigan, "Heating and Ventilation of Passenger and Goods Vehicles," F. Duncombe, 7.30 p.m.——London Centre: Visit to Maidstone and District Motor Services, Ltd., Maidstone, 2.30 p.m.

Thurs., Sept. 20th.—N.E. Centre: Hotel Metropole, Leeds, "Garage Equipment and Service Tools," R. M. Walker, 7.30 p.m.

Institution of Locomotive Engineers

Wed., Sept. 19th.—Institution of Mechanical Engineers, Storey's Gate, St. James's Park, S.W.1, "Dynamic Braking for Steam, Diesel and Gas Turbine Locomotives," J. Koffman, 5.30 p.m.

Institution of Mechanical Engineers

To-day, Sept. 14th.—Institution of Civil Engineers of Ireland, 35, Dawson Street, Dublin, "The Application of Gas Turbine Technique to Steam Power," J. F. Field, 6.15 p.m.

Sat., Sept. 22nd.—N.W. Graduate Section: Engineers' Club, Albert Square, Manchester, "High-Pressure Steam Boilers," G. Cooke, 2.30 p.m.

Wed., Sept. 26th.—Southern Branch: Technical College, Brighton, discussion, "Britain—Liquid Fuel—Engineers," introduced by Captain (E.) H. Moy, 7 p.m.

Thurs., Sept. 27th.—N. W. Branch: Engineers' Club, Albert Square, Manchester, "Some Problems in the Manufacture of Experimental Gas Turbines," L. H. Leedham, 6.45 p.m.

Institution of Production Engineers

Mon., Oct. 1st.—Western Section: Grand Hotel, Bristol, Formation of Graduate Section, 7.15 p.m.

Tues., Oct. 2nd.—Reading Section: Great Western Hotel, Reading, "Industrial Incentives," R. N. Marland, 7.15 p.m.

Wed., Oct. 3rd.—Nottingham Section: Victoria Station Hotel, Nottingham, "The Fatigue of Metals" J. A. Pope, 7 p.m.——South Essex Section: S.E. Essex Technical College, Barking, "The Problems of Modern Management," Lewis C. Ord, 7.30 p.m.——Dundee Section: Imperial Hotel, Arbroath, "Cast Iron as an Engineering Material," H. T. Angus, 7.30 p.m.

Thurs., Oct. 4th.—London Section: Royal Empire Society, Northumberland Avenue, W.C.2, "Increased Productivity by the Use of Compressed Air," N. P. Watts, 7 p.m.

Fri., Oct. 5th.—West Wales Section: Central Library, Alexandra Road, Swansea, "History and Development of the Tube Industry," W. Goldsworthy, 7.30 p.m.

Institution of Works Managers

Sat., Sept. 15th.—Notts and Derby Branch: Visit to Power Station, Wilford Road, Nottingham.

Mon., Sept. 17th.—Glasgow Branch: Institution of Engineers and Shipbuilders in Scotland, 39, Elmbank Crescent, Glasgow, "Job Evaluation," R. Aston, 7.15 p.m.

Royal Aeronautical Society

Thurs., Oct. 4th.—Institution of Civil Engineers, Great George Street, S.W.1, Seventh British Commonwealth and Empire Lecture, "Air Transport in New Zealand and the South Pacific," Air Vice-Marshal Sir L. M. Isitt, R.N.Z.A.F., 6 p.m.

Stephenson Locomotive Society

Sat., Sept. 15th.— Visit to Ashford Locomotive Works and Running Shed, S.R., from 2.45 p.m.

Contracts

During the past month the British Electricity Authority has placed contracts for equipment for power stations, transforming stations and transmission lines amounting in the aggregate to £4,203,375. The principal contracts include: Acton Lane "B" power station, generator, station and unit transformers (Ferranti, Ltd.); Littlebrook "C" power station, 11kV, 6kV and low-tension power and control cables and accessories (Henley's Telegraph Works Company, Ltd.); East Yelland power station, near Barnstaple, foundations for second half of main building (Taylor Woodrow Construction, Ltd.); Bold power station, St. Helens, Lancs, coal handling plant (Naylor Brothers, Ltd.); Doncaster power station, civil engineering works (Higgs and Hill, Ltd.); Skelton Grange power station, Leeds, extension of boiler-house foundations and ancillary works (Harold, Arnold and Son, Ltd.); Stella North power station, Blaydon-on-Tyne, site clearance and preliminary works (Sir Robert McAlpine (Newcastle-upon-Tyne), Ltd.); Carrington power station, Manchester, three 360,000 lb per hour boilers (John Brown and Co., Ltd.); Fleetwood power station, generator and unit transformers (English Electric Company, Ltd.); Roosecote power station, Barrow, boiler-house buildings (Dorman Long and Co., Ltd.); Ince power station, Capenhurst, 132kV, 2500MVA switchgear (English Electric Company, Ltd.); Llanelly substation, Carmarthen, 33kV and 11kV static condensers (British Insulated Callender's Cables, Ltd.); Bonnybridge substation, Stirling, 132kV switchgear (British Thomson-Houston Company, Ltd.); Longstone-Gorgie-Telford Road, S.E. Scotland, 132kV and 33kV cables (Pirelli-General Cable Works, Ltd.).

Launches and Trial Trips

Seniority, motor coaster; built by the Goole Shipbuilding and Repairing Company, Ltd., for F. T. Everard and Sons, Ltd.; length 225ft, breadth moulded 37ft 10in, depth moulded 16ft, deadweight 1800 tons; Newbury diesel engine, 800 b.h.p. at 250 r.p.m. Launch, August 18th.

Tank King, motor tanker; built by Harland and Wolff, Ltd., for Sigurd Herlofson and Co., Oslo; length between perpendiculars 580ft, breadth moulded 78ft, depth moulded 42ft 6in, deadweight 24,000 tons; twenty-seven cargo oil tanks, two pump rooms, steam deck machinery; single-acting, two-cycle eccentric opposed piston, Harland-Burmeister and Wain oil engine, seven cylinders 750mm diameter by 2000mm combined stroke, 110 r.p.m., two single-ended cylindrical multi-tubular boilers. Trial, August 31st.

Sydenham, collier; built by the Burntisland Shipbuilding Company, Ltd., for the South-Eastern Gas Board; length between perpendiculars 265ft 10in, breadth 39ft 6in, depth moulded 18ft 6in, deadweight 2875 tons, loaded draught 17ft 1¼in; British Polar diesel engine, eight cylinders, 340mm diameter by 570mm stroke, 1150 b.h.p. Trial, September 6th.